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ASRB NEMATOLOGY
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06. NEMATOLOGY

Unit 1: History and Economic Importance
History and economic importance of nematology; Diseases caused by plant-parasitic nematodes-symptomatology, biology, distribution and management of plant parasiticnematodes of economic importance *(Pratylenchus, Radopholus, Hirschmanniella, Meloidogyne, Heterodera, Globodera, Rotylenchulus, Tylenchulus, Ditylenchus, Anguina, Aphelenchoides, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Scutellonema, Paratylenchus,* etc.). Entomopathogenic nematodes.

Unit 2: Nematode Taxonomy and Morphology
Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny andsystematics. Molecular taxonomy. Classification of soil and plant -parasitic nematodes and their relationships with other related phyla. Detailed classification of plant -parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes. Various systems: digestive, excretory, nervous, reproductive etc., developmental biology of nematodes.

Unit 3: Nematological Techniques Methods of extraction of nematodes from soil and plant material. Microscopy principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology and culturing of nematodes -plant parasitic, entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular techniques for nematode diagnosis. Techniques for mass culturing of nematode antagonistic bioagents.

Unit 4: Nematode Ecology
Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modeling. Community analysis.

NODA

Unit 5: Plant Nematode Relationships
Types of parasitism in nematodes. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved. Pathotypes in nematodes. Mechanism ofnematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

Unit 6: Nematode Physiology and Cytology
Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of muscular, nervous and sensory responses. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Nematode as biological models-*Caenorhabditis elegans*. Cytological changes in plants dueto infection including formation of feeding cells such as syncytia and giant cells.

Unit 7: Nematode Management
Principles and methods of nematode management -physical, cultural biological, chemical and legislative, Nematicides (including those of biological origin) -history, classification, formulations, application and mode of action. Host resistance for nematode management. Integrated nematode management. Role of biotechnology, nematode genomics and transcriptomics in nematode management.

Unit 8: Interactions of Nematodes with Soil Organisms
Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorrhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

Unit 9: Statistics
Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions- normal, binomial and poisson. Correlations: partial and multiple. Tests of significance: t, F and Chi square tests. Experimental designs - randomized block, Latin square and split plot designs, their analysis and interpretation.

CHAPTER 01
History and Economic Importance

2025

1. Who is credited with the discovery of the first plant-parasitic nematode in 1743?
(A) Turbevill Needham
(B) M. J. Berkeley
(C) Hermann Schacht
(D) Julius Kuhn

2017

2. Which pioneering nematologist published the first comprehensive manual on plant nematology and is widely recognized as the father of modern nematology?
(A) B. G. Chitwood
(B) H. C. Bastian
(C) N. A. Cobb
(D) J. G. de Man

2006

3. What significant contribution did Hermann Schacht make to the field of nematology in 1859?
(A) Discovered the sugarbeet cyst nematode
(B) Described the first root-knot nematode
(C) Identified the causative agent of ear cockle in wheat
(D) Developed the first nematicide

2017

4. M. J. Berkeley is historically recognized for which of the following milestones in nematology?
(A) Documented the first known occurrence of a foliar nematode
(B) Describing the structure of the nematode cuticle
(C) Identified the first species of entomopathogenic nematodes
(D) First reported root-knot nematode galls on cucumber

2001

5. Which of the following statements about Julius Kuhn's contribution to nematology is INCORRECT?
(A) He was an early pioneer in soil fumigation
(B) He discovered the first virus-vector nematode
(C) He identified the stem and bulb nematode
(D) He conducted extensive studies on the sugarbeet cyst nematode

2017

6. Who among the following established the basic morphological and anatomical framework of nematodes in the mid-20th century, culminating in the text "An Introduction to Nematology"?
(A) N. A. Cobb
(B) A. L. Taylor
(C) B. G. Chitwood
(D) Gerald Thorne

2024

7. The first report of a plant-parasitic nematode in India was the discovery of root-knot nematode on tea. Who reported this finding?
(A) E. J. Butler
(B) P. N. Krishna Ayyar
(C) A. R. Seshadri
(D) C. A. Barber

2011

8. What major contribution did E. J. Butler make to the history of Indian agricultural nematology?
(A) Described the Ufra disease of rice
(B) Founded the Nematological Society of India
(C) First reported the golden cyst nematode in Nilgiris
(D) Discovered the citrus nematode in Punjab

2009

9. P. N. Krishna Ayyar's early work in India was primarily associated with the discovery of which nematode?
(A) Rice root nematode
(B) Root-knot nematode on cotton
(C) Potato cyst nematode
(D) Root-knot nematode on vegetables

2023

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): N. A. Cobb contributed significantly to nematode taxonomy and morphology.
Reason (R): N. A. Cobb developed the formula for nematode measurements that remains foundational in nematology.
(A) Both A and R are true and R is the correct

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explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

11. Which Indian nematologist played a pivotal role in establishing the Division of Nematology at IARI, New Delhi?
(A) A. R. Seshadri
(B) E. J. Butler
(C) C. A. Barber
(D) M. R. Siddiqi

2001

12. Plant-parasitic nematodes cause an estimated annual global crop yield loss of approximately what percentage?
(A) 2-5%
(B) 10-14%
(C) 25-30%
(D) 40-50%

2024

13. Which of the following best explains the quarantine significance of plant-parasitic nematodes?
(A) They typically infect only a single host species within specific regions
(B) They possess the ability to move rapidly over very long distances in soil
(C) They are visible to the naked eye, allowing easy inspection
(D) They survive adverse conditions and spread easily via soil or plant material

2014

14. What is the primary method used to estimate crop yield losses caused by nematodes in the field?
(A) Analyzing the total leaf chlorophyll content in the canopy
(B) Counting the number of adult nematodes on the soil surface
(C) Comparing yields between nematicide-treated and untreated plots
(D) Maintaining records of the total seasonal rainfall across the field

2025

15. Which of the following statements about the economic impact of nematodes is correct?
(A) Nematodes only reduce yield, not crop quality
(B) Soil-borne nature makes nematode eradication virtually impossible
(C) Nematode damage is usually uniformly distributed in a field
(D) Symptoms of nematode infection are distinct and not confused with nutrient deficiency

NODIA

2005

16. What is the outermost covering of a plant-parasitic nematode called?
(A) Epidermis
(B) Hypodermis
(C) Exoskeleton
(D) Cuticle

2008

17. The hypodermis in a typical nematode forms longitudinal chords. How many such chords are usually present?
(A) Two
(B) Four
(C) Six
(D) Eight

2022

18. Which morphological structure is an essential diagnostic feature differentiating plant-parasitic nematodes from free-living nematodes?
(A) Amphids
(B) Phasmids
(C) Stylet
(D) Spicules

2009

19. Identify the INCORRECT statement regarding the digestive system of plant-parasitic nematodes.
(A) The intestine is lined with a rigid cuticle that sheds during molting
(B) It consists of a stoma, esophagus, intestine, and rectum
(C) The median bulb functions as a muscular pumping organ
(D) The esophageal glands secrete digestive enzymes

2025

20. Match the nematode reproductive structures in List I with their functions in List II.
List I: (Structure)
P. Spicules
Q. Gubernaculum
R. Bursa
S. Spermatheca
List II: (Function)
1. Stores sperm in females
2. Aids in grasping the female
3. Guides spicules during copulation

4. Intromittent organs in males
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-2, R-3, S-4

2002

21. Which part of the nematode esophagus contains the dorsal and subventral gland cells?
(A) Basal bulb
(B) Corpus
(C) Isthmus
(D) Metacorpus

2018

22. In the male nematode reproductive system, the vas deferens opens into which structure?
(A) Anus
(B) Vulva
(C) Rectum
(D) Cloaca

2003

23. What type of reproductive strategy involves the development of unfertilized eggs into viable offspring?
(A) Parthenogenesis
(B) Amphimixis
(C) Hermaphroditism
(D) Syngamy

2011

24. What is the typical number of juvenile stages in the life cycle of a plant-parasitic nematode?
(A) Two
(B) Three
(C) Four
(D) Five

2004

25. Which phenomenon occurs during the transition from one juvenile stage to the next in nematodes?
(A) Pupation
(B) Ecdysis
(C) Metamorphosis
(D) Encystment

2003

26. In most plant-parasitic nematodes, which juvenile stage typically hatches from the egg?
(A) J1
(B) J3
(C) J4
(D) J2

2022

27. Where does the first molt (J1 to J2) usually occur in the life cycle of most plant-parasitic nematodes?
(A) In the soil
(B) Inside the host root
(C) On the root surface
(D) Inside the egg

2012

28. Which of the following is an exception where the first stage juvenile (J1) hatches from the egg?
(A) Xiphinema
(B) Meloidogyne
(C) Heterodera
(D) Globodera

2010

29. The process of embryogenesis in nematodes begins with which event?
(A) Formation of the blastula
(B) Cleavage of the zygote
(C) Gastrulation
(D) Formation of the vermiform stage

2016

30. Consider the following statements regarding nematode molting:
I. Molting involves the synthesis of a new cuticle.
II. The old cuticle is partially or completely shed.
III. Molting occurs only once during the nematode's lifespan.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2006

31. Based on feeding behavior, how are nematodes that feed from the outside of the root without completely entering it classified?
(A) Endoparasites
(B) Semi-endoparasites
(C) Predators
(D) Ectoparasites

2021

32. Which of the following nematodes is a classic example of a migratory endoparasite?
(A) Meloidogyne incognita
(B) Heterodera avenae
(C) Tylenchulus semipenetrans
(D) Pratylenchus penetrans

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2002

33. Sedentary endoparasites are characterized by which defining behavior?
(A) Establishing a permanent feeding site inside the root
(B) Moving continuously through root tissues while feeding
(C) Feeding only on root hairs from the soil
(D) Partially penetrating the root leaving the posterior body exposed

2014

34. What classification best describes the feeding behavior of Rotylenchulus reniformis?
(A) Migratory endoparasite
(B) Sedentary ectoparasite
(C) Migratory ectoparasite
(D) Semi-endoparasite

2017

35. Which symptom is a typical above-ground indication of a severe root nematode infection?
(A) Chlorosis and stunting
(B) Formation of root galls
(C) Appearance of stubby roots
(D) Presence of root lesions

2023

36. Which nematode genus is characterized by having a thick, heavily annulated cuticle and a very slow, sluggish movement?
(A) Meloidogyne
(B) Heterodera
(C) Ditylenchus
(D) Criconemoides

2004

37. Root lesions, characterized by necrotic areas on the root surface, are primarily caused by the invasion of which nematode?
(A) Globodera
(B) Aphelenchoides
(C) Anguina
(D) Pratylenchus

2021

38. Which nematode genus is known for inducing the formation of distinctive root galls or knots?
(A) Meloidogyne
(B) Radopholus
(C) Hirschmanniella
(D) Hoplolaimus

2012

39. Identify the correct pair matching the nematode genus to its characteristic below-ground symptom.
(A) Heterodera - Root galls
(B) Globodera - Cysts on roots
(C) Pratylenchus - Stubby root
(D) Trichodorus - Root lesions

2006

40. Consider the following statements regarding Meloidogyne species:
I. They are migratory endoparasites.
II. Second-stage juveniles (J2) are the infective stage.
III. They induce the formation of specialized giant cells.
IV. Females remain vermiform throughout their life cycle.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II and III
(C) I and IV
(D) II and IV

2017

41. What is the primary function of giant cells induced by root-knot nematodes?
(A) To act as a protective barrier against soil pathogens
(B) To facilitate rapid water transport to the upper plant parts
(C) Serve as nutrient sinks for the developing nematode
(D) To synthesize specific toxins that kill surrounding plant tissue

2014

42. How do giant cells in Meloidogyne infections typically form?
(A) By cell wall breakdown and fusion of adjacent cells
(B) By rapid cellular dehydration
(C) By programmed cell death of cortical cells
(D) By repeated mitosis without cytokinesis

2010

43. Which of the following is NOT a major species of root-knot nematode affecting agricultural crops?
(A) Meloidogyne tritici
(B) Meloidogyne incognita
(C) Meloidogyne javanica
(D) Meloidogyne arenaria

2011

44. What morphological feature is commonly used for species identification in adult female Meloidogyne?
(A) Stylet length

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(B) Tail shape
(C) Number of head annules
(D) Perineal pattern

2006

45. In integrated management of root-knot nematodes, which biological control agent is frequently utilized to parasitize nematode eggs?
(A) Trichoderma viride
(B) Purpureocillium lilacinum
(C) Bacillus thuringiensis
(D) Beauveria bassiana

2015

46. What distinguishing morphological feature defines the adult female of Heterodera species?
(A) Maintaining a characteristically vermiform shape
(B) Possessing a notably and exceptionally long stylet
(C) Possessing a distinct and clear pre-anal vulva
(D) Developing a lemon-shaped body that forms a hard cyst

2009

47. Which specialized feeding structure is induced by Heterodera species within the host root?
(A) Syncytia
(B) Giant cells
(C) Nurse cells
(D) Gall cells

2017

48. Unlike giant cells, syncytia induced by cyst nematodes are formed through which cellular process?
(A) Occurring through the process of repeated endomitosis
(B) Cell wall dissolution and fusion of neighboring protoplasts
(C) Intensive hyperplasia of the localized cortical cells
(D) Vacuolar expansion

2024

49. Heterodera avenae is an economically important cyst nematode primarily infecting which crop?
(A) Wheat
(B) Soybean
(C) Pigeonpea
(D) Potato

2017

50. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cyst nematodes can survive in the soil for many years even in the absence of a host.
Reason (R): The dead body of the female hardens to form a protective cyst around the eggs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

51. Heterodera cajani is a major constraint in the production of which leguminous crop?
(A) Pigeonpea
(B) Chickpea
(C) Soybean
(D) Mungbean

NODIA

2015

52. Which species of Heterodera is globally recognized as a devastating pest of soybean?
(A) Heterodera schachtii
(B) Heterodera zeae
(C) Heterodera avenae
(D) Heterodera glycines

2016

53. What is the most effective cultural practice for managing soybean cyst nematode?
(A) Flooding the field
(B) Crop rotation with non-host crops
(C) Deep summer ploughing
(D) Applying high doses of nitrogen fertilizer

2005

54. Globodera rostochiensis and Globodera pallida are collectively known as which type of nematode?
(A) Sugarbeet cyst nematodes
(B) Cereal cyst nematodes
(C) Carrot cyst nematodes
(D) Potato cyst nematodes

2003

55. In India, the distribution of potato cyst nematodes is predominantly restricted to which geographical region?
(A) Indo-Gangetic plains
(B) Nilgiri and Palani hills
(C) Thar Desert
(D) Brahmaputra valley

2014

56. What morphological characteristic differentiates Globodera cysts from Heterodera cysts?
(A) Globodera cysts are characteristically lemon-shaped
(B) Globodera cysts lack any distinct cuticular pattern
(C) Globodera cysts are transparent
(D) Globodera cysts are spherical, lacking a terminal cone

2002

57. The existence of different pathotypes in Globodera species complicates which management strategy?
(A) Chemical control
(B) Biological control
(C) Soil solarization
(D) Breeding for resistant varieties

2014

58. Domestic quarantine regulations in India are strictly enforced to prevent the spread of potato cyst nematode from Tamil Nadu. Which act governs these regulations?
(A) Environment Protection Act
(B) Destructive Insects and Pests (DIP) Act
(C) Seed Act
(D) Plant Quarantine Order

2013

59. Which phenomenon stimulates the hatching of Globodera eggs in the soil?
(A) Exudates from potato roots
(B) High soil temperature
(C) Heavy rainfall
(D) Decrease in soil pH

2025

60. Consider the following statements regarding Pratylenchus species:
I. They are sedentary endoparasites.
II. All juvenile stages and adults can infect roots.
III. They cause necrotic lesions on roots.
IV. They feed exclusively on root hairs.
V. They have a wide host range.
Which of the above statement(s) is/are INCORRECT?
(A) I and IV
(B) II and III
(C) I, IV and V
(D) II, III and V

2014

61. Pathogenesis by Pratylenchus species involves extensive tissue damage primarily within which root layer?
(A) Cortex
(B) Epidermis
(C) Endodermis
(D) Xylem

2011

62. Which species of lesion nematode is particularly damaging to coffee in global agriculture?
(A) Pratylenchus penetrans
(B) Pratylenchus coffeae
(C) Pratylenchus brachyurus
(D) Pratylenchus thornei

2014

63. How do lesion nematodes facilitate secondary infections in host plants?
(A) By secreting specific and localized immunosuppressive proteins
(B) By vectoring specific plant viruses directly into the xylem tissues
(C) By altering the composition of the soil microbiome entirely
(D) Creating wounds that serve as entry points for fungi and bacteria

2022

64. Radopholus similis is the primary causal agent of which severe disease in banana?
(A) Panama wilt
(B) Sigatoka leaf spot
(C) Moko disease
(D) Toppling disease

2024

65. The term "spreading decline" is associated with Radopholus similis infection in which crop?
(A) Citrus
(B) Black pepper
(C) Banana
(D) Sugarcane

2014

66. Which disease complex in black pepper is heavily exacerbated by the presence of Radopholus similis?
(A) Quick wilt
(B) Pollu disease
(C) Little leaf
(D) Slow decline (Pepper yellows)

2024

67. What is a key biological feature of the adult male Radopholus similis?

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(A) It develops into a hard cyst
(B) It serves as the primary infective life stage
(C) It is significantly larger than the adult female
(D) It has a degenerate stylet and does not feed

2018

68. Radopholus similis belongs to which feeding behavior group?
(A) Migratory endoparasite
(B) Sedentary endoparasite
(C) Migratory ectoparasite
(D) Semi-endoparasite

2022

69. Which method is highly recommended for obtaining nematode-free banana planting material to manage Radopholus similis?
(A) Paring and hot water treating corms
(B) Selecting large suckers that have intact root systems
(C) Applying a soaking of leaves in standard nematicides
(D) Freezing the suckers for a short time before planting

2006

70. Match the nematodes in List I with their characteristic disease/symptoms in List II.
List I: (Nematode)
P. Radopholus similis
Q. Heterodera avenae
R. Meloidogyne incognita
S. Tylenchulus semipenetrans
List II: (Disease/Symptom)
1. Root galls
2. Slow decline
3. Toppling disease
4. Molya disease
(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2005

71. Hirschmanniella species are widely recognized as major pests of which ecosystem?
(A) Arid deserts
(B) Temperate forests
(C) High-altitude orchards
(D) Flooded rice systems

2009

72. Which specific nematode is commonly referred to as the "rice root nematode"?
(A) Meloidogyne graminicola
(B) Ditylenchus angustus
(C) Aphelenchoides besseyi
(D) Hirschmanniella oryzae

2005

73. How does Hirschmanniella oryzae primarily survive during the off-season in rice fields?
(A) As cysts in dry soil
(B) In roots of self-sown rice and weed hosts
(C) By forming anhydrobiotic coils
(D) As eggs encased in a gelatinous matrix

2008

74. Which stage of Hirschmanniella is infective to rice roots?
(A) Only J2
(B) All juvenile stages and adults
(C) Only adults
(D) Only J4

2017

75. The genus Rotylenchulus is characterized by kidney-shaped mature females and is commonly known as the:
(A) Reniform nematode
(B) Spiral nematode
(C) Lance nematode
(D) Ring nematode

2009

76. The mature female of Rotylenchulus reniformis exhibits which distinctive shape?
(A) Lemon-shaped
(B) Kidney-shaped
(C) Spherical
(D) Vermiform

2005

77. Which statement correctly describes sexual dimorphism in Rotylenchulus reniformis?
(A) The males are kidney-shaped, while the females remain vermiform
(B) Both sexes are spherical, though males are noticeably larger
(C) Females become kidney-shaped; males stay slender and non-feeding
(D) The males possess a strong stylet, whereas females lack a stylet

2025

78. In the life cycle of the reniform nematode, where do the molts from J2 to pre-adult typically occur?
(A) Inside the host root
(B) Inside the egg
(C) On the root surface after feeding
(D) In the soil without feeding

NODIA

2002

79. What is the infective stage of Rotylenchulus reniformis?
(A) J2
(B) Immature female
(C) Adult male
(D) J4

2016

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The reniform nematode is classified as a semi-endoparasite.
Reason (R): The anterior portion of the female penetrates the root while the posterior remains outside in the soil.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

81. Tylenchulus semipenetrans is the primary causative agent of which citrus disease?
(A) Citrus canker
(B) Citrus greening
(C) Slow decline of citrus
(D) Citrus tristeza

2022

82. Which life stage of the citrus nematode is responsible for establishing the permanent feeding site?
(A) J2 female
(B) J4 male
(C) Mature male
(D) Immature female

2011

83. The feeding site of Tylenchulus semipenetrans comprises a specialized group of cells known as:
(A) Nurse cells
(B) Giant cells
(C) Syncytia
(D) Gall cells

2005

84. What happens to the posterior body of the mature female Tylenchulus semipenetrans?
(A) It swells and protrudes from the root surface
(B) It hardens into a cyst
(C) It becomes completely enclosed within the vascular tissue
(D) It detaches and forms an egg sac in the soil

2021

85. The existence of biotypes in Tylenchulus semipenetrans is determined based on:
(A) Specific and distinct morphological differences in the average stylet length
(B) Ability to parasitize and reproduce on different indicator hosts (e.g., Poncirus trifoliata, olive)
(C) Their inherent level of tolerance to varying levels of soil pH
(D) The specific and localized geographical location of the population alone

2015

86. Which nematode genus includes the stem and bulb nematodes?
(A) Anguina
(B) Aphelenchoides
(C) Ditylenchus
(D) Bursaphelenchus

2006

87. Ditylenchus dipsaci primarily affects which type of plant tissues?
(A) Roots and tubers
(B) Above-ground stems, leaves, and bulbs
(C) Xylem vessels
(D) Root hairs

2025

88. What is the principal survival mechanism of Ditylenchus dipsaci under desiccating conditions?
(A) Forming protective cysts
(B) Entering a state of anhydrobiosis
(C) Deep soil vertical migration
(D) Sporulation

2023

89. The "nematode wool" refers to aggregated, desiccated masses of which nematode?
(A) Meloidogyne incognita
(B) Ditylenchus dipsaci
(C) Radopholus similis
(D) Globodera pallida

2024

90. Consider the following statements regarding Ditylenchus dipsaci:
I. It is an obligate root parasite.
II. It possesses a very strong and robust stylet.
III. It produces a pectinase enzyme that dissolves middle lamellae of host cells.
IV. It causes swelling and distortion of stems and leaves.

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Which of the above statement(s) is/are correct?
(A) I and II
(B) III and IV
(C) II and III
(D) I and IV

2021

91. Anguina tritici is responsible for causing which disease in wheat?
(A) Loose smut
(B) Karnal bunt
(C) Ear cockle disease
(D) Powdery mildew

2017

92. The infective stage of Anguina tritici that emerges from the seed gall is the:
(A) J2
(B) J1
(C) J3
(D) Adult

2014

93. Anguina tritici serves as a vector for which pathogenic bacterium, causing yellow ear rot (tundu) disease?
(A) Pseudomonas syringae
(B) Rathayibacter tritici
(C) Xanthomonas campestris
(D) Agrobacterium tumefaciens

2005

94. What is the most practical and traditional method for separating Anguina tritici galls from healthy wheat seeds?
(A) Chemical seed dressing
(B) Floating the seeds in a 20% brine solution
(C) Freezing the seeds
(D) Winnowing

2014

95. Which group of nematodes is primarily characterized as foliar nematodes?
(A) Aphelenchoides
(B) Xiphinema
(C) Longidorus
(D) Trichodorus

2010

96. Aphelenchoides besseyi is the causal agent of which significant disease in rice?
(A) Blast disease
(B) Ufra disease
(C) White tip disease
(D) Sheath blight

2003

97. How does Aphelenchoides besseyi disseminate to the upper parts of the rice plant?
(A) Through the xylem tissue
(B) By migrating up the stem in a film of water
(C) Via airborne spores
(D) Conveyed by insect vectors

2012

98. Which crop management technique is highly effective in eradicating Aphelenchoides besseyi from rice seeds?
(A) Sun drying for one hour
(B) Hot water treatment at 52-54°C for 15 minutes
(C) Storing seeds below freezing
(D) Washing seeds with distilled water

NODIA

2025

99. Aside from rice, Aphelenchoides species are notoriously devastating to which industry?
(A) Sugarcane production
(B) Floriculture (ornamental plants like Chrysanthemum)
(C) Forestry
(D) Turfgrass management

2014

100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Aphelenchoides species have a well-developed metacorpus occupying most of the body width.
Reason (R): The large metacorpus is a diagnostic feature of nematodes belonging to the order Aphelenchida.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

101. Tylenchorhynchus species are commonly referred to as:
(A) Stunt nematodes
(B) Spiral nematodes
(C) Lance nematodes
(D) Pin nematodes

2004

102. What is the characteristic feeding behavior of Tylenchorhynchus species?
(A) Migratory endoparasite

(B) Migratory ectoparasite
(C) Sedentary endoparasite
(D) Semi-endoparasite

2010

103. The primary crop impact of stunt nematodes is best described by which symptom?
(A) Presence of many deep and necrotic root lesions
(B) The formation of many large and visual root galls
(C) General reduction in the root system and severe stunting of the plant
(D) Resulting in the complete rotting of the whole root system

2025

104. Helicotylenchus species derive their common name, "spiral nematodes," from what characteristic?
(A) The spiral shape of their stylet
(B) The characteristic spiral pattern of their active movement within the soil
(C) Their habit of curling into a spiral shape when relaxed or dead
(D) The unique and distinct spiral shape of their produced egg masses

2005

105. Helicotylenchus multicinctus is a major pest of which crop worldwide?
(A) Wheat
(B) Banana
(C) Potato
(D) Cotton

2021

106. Hoplolaimus species are robust nematodes commonly known as:
(A) Dagger nematodes
(B) Needle nematodes
(C) Lance nematodes
(D) Ring nematodes

2021

107. Which morphological feature is distinct in the head region of Hoplolaimus species?
(A) A very long, needle-like stylet
(B) A heavily sclerotized cephalic framework
(C) Absence of a stylet
(D) A large lip cap

2022

108. Scutellonema species are commonly known as "yam nematodes" because they cause:
(A) Dry rot of yam tubers
(B) Soft rot of yam tubers
(C) Galling of yam roots
(D) Excessive branching of yam tubers

2017

109. What specialized morphological feature characterizes the genus Scutellonema?
(A) Overlapping esophageal glands dorsally
(B) Enlarged phasmids called scutella at the tail region
(C) Two ovaries
(D) A single outstretched ovary

2021

110. Paratylenchus species are commonly referred to as:
(A) Stubby-root nematodes
(B) Pin nematodes
(C) Sting nematodes
(D) Cyst nematodes

2005

111. Which characteristic accurately describes the morphology of adult female Paratylenchus?
(A) Possess an unusually long stylet relative to small body size
(B) They are classified among the largest of all plant-parasitic nematodes
(C) They lack a stylet entirely
(D) They typically become quite spherical upon reaching full maturation

2025

112. Consider the following statements regarding Entomopathogenic Nematodes (EPNs):
I. Steinernema and Heterorhabditis are the two primary genera.
II. They parasitize a wide range of plant roots.
III. They have a mutualistic association with specific bacteria.
IV. The infective juvenile is the only free-living stage in the soil.
V. They kill their insect hosts within 24-48 hours.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II only
(C) III and V
(D) IV and V

2024

113. The specialized stage of EPNs that survives in the soil and seeks out insect hosts is the:
(A) Infective Juvenile (IJ) or J3
(B) J1

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(C) J2
(D) J4

2017

114. Which foraging strategy involves the infective juvenile standing on its tail and actively waiting to ambush a passing insect?
(A) Ambushing
(B) Cruising
(C) Trapping
(D) Grazing

2009

115. Steinernema carpocapsae is considered a classic example of an EPN utilizing which host-finding strategy?
(A) Ambushing
(B) Cruising
(C) Intermediate
(D) Sedentary

2008

116. Heterorhabditis bacteriophora typically utilizes which host-finding strategy to locate sedentary insects deep in the soil?
(A) Ambushing
(B) Cruising
(C) Nictation
(D) Passive diffusion

2003

117. How do infective juveniles of EPNs typically enter the insect host?
(A) By directly piercing the rigid insect exoskeleton with a stylet
(B) Exclusively by being ingested during the process of insect feeding
(C) Through natural openings such as the mouth, anus, or spiracles
(D) Through various wounds that are created by other soil predators

2022

118. What morphological structure do EPN infective juveniles retain from the previous molt to protect against environmental stress?
(A) J2 cuticle
(B) J1 cuticle
(C) Eggshell
(D) Cyst wall

2023

119. Once inside the insect hemocoel, what critical action does the EPN infective juvenile perform?
(A) It begins feeding immediately on insect fat bodies
(B) It releases its mutualistic symbiotic bacteria
(C) It encysts in the muscle tissue
(D) It molts directly into an adult male

2010

120. Match the EPN genus in List I with its specific symbiotic bacterial genus in List II.
List I: (EPN Genus)
P. Steinernema
Q. Heterorhabditis
List II: (Bacterial Genus)
1. Photorhabdus
2. Xenorhabdus
3. Bacillus
4. Pseudomonas
(A) P-2, Q-1
(B) P-1, Q-2
(C) P-3, Q-4
(D) P-4, Q-3

2002

121. The symbiotic bacteria of EPNs cause rapid insect mortality primarily by:
(A) Suffocation of the host
(B) Causing fatal septicemia and releasing toxins
(C) Consuming the host's brain
(D) Paralysis through neurotoxins

2004

122. Besides killing the insect, what other crucial function do the symbiotic bacteria serve for the nematodes?
(A) Convert host tissues into a suitable food source for the nematodes
(B) They function as an effective transport vehicle within the soil
(C) They protect the nematode from the effects of soil desiccation
(D) They allow the nematode to successfully infect various plant roots

NODIA

2024

123. Photorhabdus bacteria, associated with Heterorhabditis, possess a unique characteristic visible in the dark. What is it?
(A) They emit a strong odor
(B) They change color to bright red
(C) They vibrate audibly
(D) They are bioluminescent

2019

124. How is the symbiotic bacteria transmitted from one generation of nematodes to the next?
(A) Directly through the surrounding soil
(B) Carried in a specialized intestinal vesicle of infective juveniles

(C) Directly through the insect host's own offspring
(D) They infect the produced nematode eggs directly

2001

125. Which reproductive mechanism is uniquely present in the first generation of Heterorhabditis inside the insect host?
(A) Hermaphroditism
(B) Amphimixis
(C) Parthenogenesis
(D) Budding

2012

126. In vivo mass multiplication of EPNs is most commonly conducted using the larvae of which insect?
(A) Bombyx mori (Silkworm)
(B) Galleria mellonella (Greater wax moth)
(C) Helicoverpa armigera
(D) Spodoptera litura

2002

127. The most common method used to harvest EPN infective juveniles from insect cadavers during in vivo production is:
(A) The Baermann funnel technique
(B) White trap method
(C) Centrifugation
(D) Sieving

2021

128. For commercial-scale application, EPNs are typically produced via:
(A) Large-scale field collection
(B) In vivo rearing in millions of insects
(C) In vitro liquid fermentation in bioreactors
(D) Solid-state fermentation on agricultural waste

2015

129. During in vitro liquid fermentation of EPNs, what must be cultured in the bioreactor before introducing the nematodes?
(A) Fungal mycelium
(B) Root exudates
(C) The specific symbiotic bacteria
(D) insect hemolymph

2008

130. Consider the following statements regarding EPN formulations:
I. They can be formulated in alginate gel capsules.
II. They must be moderately desiccated to a dry powder for storage.
III. Water-dispersible granules and sponges are common carriers.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2013

131. Which environmental factor is the most detrimental to EPN survival during field application?
(A) Ultraviolet (UV) radiation from direct sunlight
(B) High soil moisture
(C) Presence of soil bacteria
(D) Cool temperatures

2012

132. To maximize efficacy, when is the best time to apply entomopathogenic nematodes in the field?
(A) Midday under full sun
(B) Early morning or late evening
(C) During a drought period
(D) Just before a hard frost

2005

133. Which equipment is most appropriate for applying EPNs as a liquid suspension to soil?
(A) Use of high-pressure and atomizing type sprayers
(B) Standard agricultural sprayers with filters removed
(C) Standard agricultural dusting machines
(D) Foggers

2006

134. What is the most relevant mechanism by which EPNs avoid host immune responses?
(A) Symbiotic bacteria produce factors suppressing the insect immune system
(B) By burying themselves deep within the host's outer cuticle
(C) By possessing a notably thick and impenetrable exoskeleton
(D) By moving much too fast for the host hemocytes to attach

NODIA

2012

135. The concept of "phase variation" in EPN symbiotic bacteria refers to:
(A) The physiological transition from J2 to J3 in the nematode
(B) Bacteria switching between primary and secondary phenotypic variants

(C) The change in the characteristic feeding behavior of the insect
(D) The complete bioluminescence cycle of Photorhabdus bacteria

2016

136. Why is the primary phase of Xenorhabdus/ Photorhabdus preferred over the secondary phase in EPN mass production?
(A) It grows much faster in distilled water
(B) Supports nematode reproduction better and produces antibiotics
(C) It is found to be strictly anaerobic
(D) It does not require any specific host

2016

137. Which historical figure established the basic taxonomy of nematodes and separated them from other helminths?
(A) Karl Rudolphi
(B) H. C. Bastian
(C) N. A. Cobb
(D) B. G. Chitwood

2002

138. The classical order Tylenchida is characterized by the presence of which morphological feature?
(A) A stomatostylet
(B) An odontostylet
(C) A mural tooth
(D) A highly developed bursa in all females

2011

139. Which nematode genus is known for transmitting nepoviruses?
(A) Xiphinema
(B) Trichodorus
(C) Meloidogyne
(D) Heterodera

2011

140. Consider the following statements regarding nematode transmission of viruses:
I. Longidorus transmits nepoviruses.
II. Trichodorus transmits tobraviruses.
III. Meloidogyne transmits potyviruses.
IV. The virus particles are retained in the stylet or esophagus lining.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) III only
(C) II and IV
(D) I and IV

2002

141. The stylet of Longidorus and Xiphinema is structurally derived from a tooth and is called:
(A) Stomatostylet
(B) Odontostylet
(C) Onchiostylet
(D) Prostylet

2006

142. Nematodes in the order Triplonchida, such as Trichodorus, possess a solid, curved stylet known as:
(A) Onchiostylet
(B) Odontostylet
(C) Stomatostylet
(D) Microstylet

2017

143. Which plant-parasitic nematode feeds near the root tip, causing the root tip to stop growing and resulting in "stubby root" symptoms?
(A) Pratylenchus
(B) Radopholus
(C) Globodera
(D) Trichodorus

2017

144. What type of esophagus is characteristic of the order Tylenchida?
(A) Three-part (corpus, isthmus, basal bulb)
(B) Two-part (cylindrical)
(C) Bottle-shaped
(D) Dorylaimoid (slender anterior, expanded posterior)

2018

145. In the Dorylaimida order, the esophagus is typically:
(A) Slender anteriorly and expanded posteriorly
(B) Equipped with a highly muscular median bulb
(C) Completely lacking a distinct basal expansion
(D) Fused with the intestine

2016

146. Which nematode is responsible for the 'Kalahasti malady' in groundnut?
(A) Meloidogyne arenaria
(B) Pratylenchus brachyurus
(C) Heterodera cajani
(D) Tylenchorhynchus brevilineatus

2011

147. Tylenchorhynchus brevilineatus causes severe stunting and pod discoloration in groundnut in which Indian state?
(A) Andhra Pradesh

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(B) Gujarat
(C) Punjab
(D) Tamil Nadu

2025

148. Which management practice is considered most effective against the cereal cyst nematode (Heterodera avenae)?
(A) Summer deep ploughing
(B) Growing susceptible wheat varieties continuously
(C) Frequent irrigation
(D) High-density planting

2021

149. The "molya" disease of wheat and barley in Rajasthan is caused by:
(A) Anguina tritici
(B) Meloidogyne graminicola
(C) Heterodera avenae
(D) Pratylenchus thornei

2015

150. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plant-parasitic nematodes possess a specialized feeding structure called a stylet.
Reason (R): The stylet is used strictly for defense against predatory nematodes in the soil.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

151. Which nematode causes the "pecky rice" symptom by feeding on developing rice grains?
(A) Aphelenchoides besseyi
(B) Ditylenchus angustus
(C) Hirschmanniella oryzae
(D) Meloidogyne graminicola

2013

152. Ditylenchus angustus is the causal organism of which devastating disease in deep-water rice?
(A) Ufra disease
(B) White tip disease
(C) Tungro disease
(D) Bakanae disease

2024

153. What is a key symptom of Ufra disease in rice?
(A) Root knotting
(B) Development of chlorosis on the lower leaves
(C) Stunted growth with crinkled and twisted panicles
(D) Formation of many deep root lesions

2011

154. How does Ditylenchus angustus survive the dry season between rice crops?
(A) As cysts in the soil
(B) In anhydrobiosis on crop residues
(C) By burrowing deep into the water table
(D) Inside rice seeds

2004

155. Which root-knot nematode species is particularly problematic in upland and rainfed lowland rice ecosystems?
(A) Meloidogyne incognita
(B) Meloidogyne javanica
(C) Meloidogyne graminicola
(D) Meloidogyne hapla

2011

156. Unlike other root-knot nematodes, where are the galls caused by Meloidogyne graminicola typically located?
(A) Terminal, often hook-like galls on root tips
(B) Only on the primary taproot
(C) Massive galls completely encompassing the root crown
(D) Above-ground stem galls

2010

157. Under which field condition is damage by Meloidogyne graminicola most severe?
(A) Continuously flooded or submerged field conditions
(B) Well-drained upland or intermittently flooded soil
(C) Saline soils
(D) High altitude fields located on terraced slopes

2022

158. What happens to Meloidogyne graminicola infection when a rice field is deeply and continuously flooded?
(A) The nematodes multiply in an exponential fashion
(B) Nematode invasion is restricted, reducing crop damage
(C) The nematodes migrate directly into the stem tissues
(D) The produced galls become much larger in size

NODIA

2022

159. Which nematode genus is known to have a mutualistic association with vesicular-arbuscular mycorrhizae (VAM), which can sometimes mitigate nematode damage?
(A) Meloidogyne
(B) Globodera
(C) Radopholus
(D) Aphelenchoides

2017

160. Consider the following statements regarding nematode survival mechanisms:
I. Diapause is a spontaneous arrest of development induced by environmental stress.
II. Quiescence is an immediate, reversible response to unfavorable conditions.
III. Anhydrobiosis is a form of quiescence induced by desiccation.
IV. Cryptobiosis involves a complete, reversible cessation of metabolism.
V. Nematodes cannot survive freezing temperatures.
Which of the above statement(s) is/are correct?
(A) II, III and IV
(B) I, II and V
(C) II, IV and V
(D) I, III and IV

2013

161. Trehalose accumulation is a critical biochemical adaptation in nematodes for surviving:
(A) High salinity
(B) Anhydrobiosis (desiccation)
(C) Heavy metal toxicity
(D) Anaerobic conditions

2004

162. Which plant hormone pathway is heavily manipulated by root-knot nematodes to induce giant cell formation?
(A) Salicylic acid
(B) Abscisic acid
(C) Auxin
(D) Ethylene

2008

163. The gelatinous matrix secreted by female Meloidogyne serves what primary purpose?
(A) To digest the surrounding root tissues and cells
(B) Protecting eggs from desiccation and microbial attack
(C) To attract male nematodes during the mating process
(D) To anchor the female firmly to the root surface

2008

164. Which organ secretes the gelatinous matrix in Meloidogyne species?
(A) Rectal glands
(B) Esophageal glands
(C) Excretory pore
(D) Vulval glands

2008

165. In a typical plant-parasitic nematode, the excretory system is located:
(A) Ventrally, near the nerve ring
(B) In the tail region
(C) Dorsally, near the stylet
(D) At the exact center of the body

2021

166. The central nervous system of a nematode consists primarily of a circumesophageal commissure, commonly known as the:
(A) Brain stem
(B) Ventral cord
(C) Dorsal ganglion
(D) Nerve ring

2014

167. Amphids are paired chemosensory organs located where on the nematode body?
(A) On the tail
(B) In the mid-body region
(C) Around the vulva
(D) Laterally on the head (lip region)

2016

168. Phasmids are sensory organs located in which region of the nematode?
(A) Head
(B) Tail region
(C) Esophagus
(D) Intestine

2010

169. Nematodes belonging to the class Adenophorea typically lack which sensory structures?
(A) Amphids
(B) Papillae
(C) Setae
(D) Phasmids

2019

170. Match the nematode structures in List I with their anatomical location/functions in List II.
List I: (Structure)
P. Stylet

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Q. Median bulb
R. Nerve ring
S. Spicule
List II: (Location/Function)
1. Muscular pump
2. Copulatory organ
3. Central nervous system
4. Feeding structure
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-3, R-1, S-4

2011

171. The excretory system in Secernentea nematodes is typically:
(A) Tubular (H-shaped or inverted U-shaped)
(B) A single glandular cell
(C) Completely absent
(D) Integrated with the digestive tract

2013

172. The presence of a bursa (caudal alae) is a distinguishing feature in the males of which group?
(A) Tylenchida
(B) Dorylaimida
(C) Aphelenchida
(D) Trichodoridae

2016

173. What is the primary method of estimating nematode population density in a soil sample?
(A) Performing direct visual counting on the soil surface
(B) Extraction via Cobb's decanting and sieving method
(C) Measuring soil respiration
(D) Performing chemical analysis of the soil nitrogen levels

2021

174. Which of the following extraction methods relies on the active movement of nematodes?
(A) Baermann funnel technique
(B) Centrifugation-flotation
(C) Fenwick can method
(D) Elutriation

2010

175. The Fenwick can method is specifically designed for the extraction of which nematode stage?
(A) Vermiform juveniles
(B) Adult males
(C) Migratory ectoparasites
(D) Cysts

2023

176. What chemical is routinely used for killing and fixing nematodes prior to mounting on microscopic slides?
(A) Ethanol
(B) Formalin-Acetic Acid (FAA) or TAF
(C) Sodium hypochlorite
(D) Acetone

2018

177. Which staining technique is commonly used to visualize nematodes inside plant roots?
(A) Gram staining
(B) Methylene blue
(C) Iodine staining
(D) Acid fuchsin in lactophenol

NODIA

2006

178. What is the fundamental difference between a nematicide and a nematistat?
(A) A nematicide kills nematodes; a nematistat inhibits them
(B) A nematicide repels nematodes, while a nematistat acts to attract them
(C) A nematicide is organic in nature, while a nematistat is synthetic
(D) A nematicide is applied to roots, but a nematistat is applied to leaves

2023

179. Carbofuran, a widely used chemical for nematode management, belongs to which chemical class?
(A) Organophosphates
(B) Carbamates
(C) Fumigants
(D) Avermectins

2024

180. Select the correct order of the typical plant-parasitic nematode life cycle stages starting from the egg.
(A) Egg → J1 → J2 → J3 → J4 → Adult
(B) Egg → J2 → J1 → J3 → J4 → Adult
(C) Egg → J1 → J2 → Adult → J3 → J4
(D) J1 → Egg → J2 → J3 → J4 → Adult

2007

181. Soil solarization, a non-chemical method for nematode control, works primarily by:
(A) Trapping solar energy to heat soil to lethal temperatures
(B) Blocking all sunlight to starve both weeds and nematodes
(C) Using UV rays to directly mutate the nematode's own DNA
(D) Increasing soil salinity

2015

182. Which organic amendment is well-known for its nematicidal properties due to the release of compounds like azadirachtin?
(A) Neem cake
(B) Bone meal
(C) Peat moss
(D) Wood ash

2025

183. Trap cropping is a cultural method used to manage nematodes. How does it work?
(A) Planting a susceptible crop and destroying it before reproduction
(B) Planting a highly resistant crop that kills nematodes as they enter
(C) Planting a specific crop that produces various volatile repellents
(D) Using sticky traps on the soil surface

2009

184. Marigold (Tagetes spp.) is often used in crop rotation to suppress root-knot nematodes. What is the active nematicidal compound released by marigold roots?
(A) Alpha-terthienyl
(B) Glucosinolate
(C) Saponin
(D) Juglone

2024

185. Pasteuria penetrans is a significant biological control agent against root-knot nematodes. What type of organism is it?
(A) Nematophagous fungus
(B) Predatory nematode
(C) Parasitic protozoan
(D) Obligate, endospore-forming bacterium

2009

186. How does Pasteuria penetrans infect its nematode host?
(A) Endospores attach, germinate, and penetrate the body cavity
(B) By being ingested during feeding
(C) By releasing specific toxins into the soil to dissolve the cuticle
(D) By parasitizing the nematode's egg mass in the soil only

2005

187. Arthrobotrys oligospora is a well-known biological control agent that utilizes which mechanism to capture nematodes?
(A) Producing sticky spores
(B) Entering through natural openings
(C) Releasing nematicidal antibiotics
(D) Forming adhesive three-dimensional hyphal networks (traps)

2004

188. Which fungus is specifically recognized as an egg parasite, frequently used against Meloidogyne and Heterodera?
(A) Trichoderma harzianum
(B) Purpureocillium lilacinum
(C) Aspergillus niger
(D) Clonostachys rosea

2010

189. Which mechanism describes how Purpureocillium lilacinum parasitizes nematode eggs?
(A) Fungal hyphae act to physically crush the eggs
(B) Fungal spores are actively ingested by the developing embryo
(C) Hyphae penetrate the eggshell and consume the contents
(D) The fungus blocks all oxygen diffusion into the egg

2014

190. Given below are the steps of the Baermann funnel extraction method:
I. Place the sample in a tissue paper lined sieve.
II. Add water to the funnel until it barely touches the bottom of the sample.
III. Collect the nematode suspension from the bottom of the funnel.
IV. Leave the setup undisturbed for 24-48 hours.
Which of the following is the correct operational sequence?
(A) I, II, IV, III
(B) II, I, IV, III
(C) I, IV, II, III
(D) II, IV, I, III

2001

191. The concept of "economic threshold level" (ETL) in nematology refers to:
(A) Population density where management is economically justified
(B) The nematode population density where complete crop failure occurs
(C) The total number of nematodes required to cause initial symptoms
(D) The cost of nematicides per hectare

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2017

192. Which genetic resistance gene (R-gene) was successfully introgressed into tomato to confer resistance against Meloidogyne species?
(A) Mi gene
(B) H1 gene
(C) Rx gene
(D) Gro1 gene

2019

193. The Mi gene in tomato provides resistance against M. incognita, M. javanica, and M. arenaria. Under what condition does this resistance break down?
(A) Low soil moisture
(B) High soil temperature (above 28°C)
(C) Excessive nitrogen fertilization
(D) Co-infection with Fusarium

2017

194. The H1 gene provides resistance in potato against which pathotype of Globodera rostochiensis?
(A) Ro1
(B) Ro2
(C) Pa1
(D) Pa3

2013

195. Which disease complex is famously known to be exacerbated by the interaction of root-knot nematodes and a specific soil-borne fungus in crops like tomato and cotton?
(A) Nematode-Fusarium wilt
(B) Nematode-Phytophthora root rot
(C) Nematode-Rhizoctonia damping off
(D) Nematode-Verticillium wilt

2024

196. How does the presence of Meloidogyne typically influence the incidence of Fusarium wilt in resistant plant varieties?
(A) It has no effect
(B) It works to completely prevent any fungal infection
(C) Infection predisposes the plant and breaks down resistance
(D) It acts to kill all the Fusarium spores

2008

197. Which synergistic interaction involves the lesion nematode (Pratylenchus penetrans) and a fungal pathogen causing "early dying syndrome" in potato?
(A) Pratylenchus + Verticillium dahliae
(B) Pratylenchus + Alternaria
(C) Pratylenchus + Phytophthora infestans
(D) Pratylenchus + Rhizoctonia solani

2008

198. The 'Kikuyu grass disease' is associated with which nematode?
(A) Meloidogyne kikuyensis
(B) Anguina agrostis
(C) Ptychocylindrus
(D) Radopholus

2006

199. What morphological adaptation allows seed gall nematodes (Anguina spp.) to climb moist plant surfaces to reach the inflorescence?
(A) Movement via water films generated by capillary action
(B) The secretion of a protective and functional slime track
(C) Prehensile tails
(D) Possession of very elongated spicules

2012

200. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Endoparasitic nematodes generally cause more severe damage to root systems than ectoparasitic nematodes.
Reason (R): Endoparasites invade and destroy internal root tissues, disrupting vascular function.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

201. The anterior-most sensory structures surrounding the stoma of a nematode are known as:
(A) Labial papillae
(B) Setae
(C) Phasmids
(D) Derids

2011

202. Which specific term refers to the sclerotized, hollow spear found in plant-parasitic nematodes?
(A) Stylet (or Stomatostylet/Odontostylet)
(B) Radula
(C) Proboscis
(D) Mandible

NODIA

2011

203. The base of the stomatostylet typically possesses three thickened structures for muscle attachment called:
(A) Knobs
(B) Shafts
(C) Cones
(D) Flanges

2022

204. In the Dorylaimida order, the stylet lacks basal knobs and instead often features:
(A) Flanges or a simple expansion
(B) A highly branched base
(C) Articulating joints
(D) Multiple distinct teeth

2021

205. The "De Man's Formula" utilizes specific letters to denote proportional measurements of nematodes. What does the letter "a" represent?
(A) Body length divided by maximum body width
(B) Body length divided by esophageal length
(C) Body length divided by tail length
(D) Position of the vulva as a percentage

2006

206. In De Man's formula, the parameter "V" stands for:
(A) Vulva distance from the anterior end as a percentage
(B) Total volume of the adult nematode
(C) Length of the ventral nerve cord
(D) The average velocity of movement

2001

207. Which genus is characterized by having females with a single ovary (monodelphic) and the vulva located very close to the posterior end?
(A) Pratylenchus
(B) Xiphinema
(C) Meloidogyne
(D) Hoplolaimus

2012

208. The term "didelphic" refers to a nematode possessing:
(A) Two ovaries
(B) Two distinct stylets
(C) Two separate digestive tracts
(D) Two excretory pores

2006

209. If a nematode ovary is "amphidelphic," it means the two ovaries are directed:
(A) Oppositely, one anteriorly and one posteriorly
(B) Both anteriorly
(C) Both posteriorly
(D) Transversely across the body

2016

210. Which plant-parasitic nematode genus typically possesses an amphidelphic reproductive system (two ovaries directed in opposite directions)?
(A) Xiphinema
(B) Pratylenchus
(C) Aphelenchoides
(D) Ditylenchus

2004

211. The presence of a prominent, overlapping esophageal gland is a key diagnostic feature separating which two genera?
(A) Tylenchorhynchus (no overlap) and Helicotylenchus
(B) Between Meloidogyne and Heterodera species
(C) Between Xiphinema and Longidorus species
(D) Between Globodera and Punctodera species

2011

212. What distinguishes the genus Punctodera from Globodera?
(A) Punctodera cysts have vulval and anal fenestrae
(B) Punctodera cysts are characteristically lemon-shaped
(C) Punctodera does not form cysts
(D) Punctodera acts as a migratory endoparasite

2002

213. Fenestration in cyst nematodes refers to:
(A) Thin areas at the cyst end that rupture for escape
(B) The characteristic pattern of ridges on the cuticle
(C) The specialized and tubes used for feeding in syncytia
(D) The excretory pore opening

2003

214. The "bull's-eye" perineal pattern is characteristically used to identify which specific species?
(A) Meloidogyne incognita
(B) Meloidogyne javanica
(C) Meloidogyne arenaria
(D) Meloidogyne hapla

2017

215. The perineal pattern of Meloidogyne javanica is uniquely identified by the presence of:

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(A) Lateral lines separating dorsal and ventral striae
(B) Presence of a high and squarish dorsal arch
(C) Presence of punctations scattered throughout the pattern
(D) Possession of a perfectly circular striae pattern

2007

216. Which of the following is a classic symptom of the citrus nematode (Tylenchulus semipenetrans)?
(A) "Dirty roots" from soil adhering to the matrix
(B) Presence of many massive and visible root galls
(C) Complete defoliation occurring within just one week
(D) The rotting of the actual fruit on the tree

2015

217. Nematode quarantine laws are primarily aimed at:
(A) Preventing introduction and spread to new areas
(B) Effectively curing already infected crop fields
(C) Developing various new chemical type nematicides
(D) Breeding of many resistant type crop varieties

2023

218. The golden nematode of potato was the primary reason for establishing the Golden Nematode Act in the USA in which year?
(A) 1912
(B) 1948
(C) 1972
(D) 1995

2007

219. Which international standard dictates the procedures for phytosanitary certification regarding nematodes and other pests?
(A) ISPM (International Standards for Phytosanitary Measures)
(B) ISO 9001
(C) Codex Alimentarius
(D) WHO Guidelines

2004

220. Match the nematode management methods in List I with their examples in List II.
List I: (Method)
P. Cultural
Q. Physical
R. Biological
S. Chemical
List II: (Example)
1. Soil solarization
2. Crop rotation
3. Oxamyl application
4. Pasteuria penetrans
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-2, S-1

2013

221. Which fumigant was historically the most widely used nematicide globally before its phase-out due to ozone depletion?
(A) Methyl bromide
(B) The compound known as Ethylene dibromide (EDB)
(C) The compound known as Chloropicrin
(D) The compound known as D-D mixture

2004

222. The international agreement responsible for the phase-out of methyl bromide is the:
(A) Montreal Protocol
(B) Kyoto Protocol
(C) Paris Agreement
(D) Cartagena Protocol

2001

223. Aldicarb, oxamyl, and carbofuran act by inhibiting which critical enzyme in the nematode nervous system?
(A) Acetylcholinesterase
(B) Cytochrome c oxidase
(C) Chitin synthase
(D) ATP synthase

2018

224. Abamectin, a natural fermentation product used as a nematicide, targets which receptor in the nematode nervous system?
(A) Glutamate-gated chloride channels
(B) Acetylcholine receptors
(C) Serotonin receptors
(D) Dopamine transporters

2021

225. Fluensulfone is a newer class of non-fumigant nematicide belonging to the group:
(A) Carbamates
(B) Fluoroalkenyl thioethers
(C) Organophosphates
(D) Neonicotinoids

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2025

226. What makes systemic nematicides (like oxamyl) highly advantageous in certain agricultural settings?
(A) Applied to foliage and translocated to protect roots
(B) They act to sterilize the soil completely
(C) They tend to persist in the soil for decades
(D) They are non-toxic to all mammals

2002

227. Soil amendments using organic matter help control nematodes primarily by:
(A) Promoting natural enemies and toxic byproducts
(B) Increasing the soil temperature in a direct way
(C) Making the roots physically harder to penetrate
(D) Creating a vacuum within the existing soil pores

2005

228. Which component released during the decomposition of brassicaceous crops (like mustard) acts as a biofumigant against nematodes?
(A) Isothiocyanates
(B) Hydrogen cyanide
(C) Tannins
(D) Alkaloids

2024

229. Which mathematical model is frequently used to describe the relationship between initial nematode population density (Π) and crop yield loss?
(A) Seinhorst's damage function model
(B) Logistic growth equation
(C) Michaelis-Menten kinetics
(D) Lotka-Volterra equations

2017

230. In Seinhorst's equation $y = m + (1 - m)z^{\{P-T\}}$, the parameter "$T$" represents:
(A) Tolerance limit (threshold below which no damage occurs)
(B) The total crop yield
(C) The minimum crop yield
(D) The ambient temperature

2005

231. The "reproductive factor" (Rf) of a nematode population is calculated by:
(A) $\frac{Pf}{Pi}$ (Final population divided by Initial population)
(B) $\frac{Pi}{Pf}$
(C) $Pf - \Pi$
(D) $\frac{Pf + Pi}{2}$

2003

232. An Rf value greater than 1 ($Rf > 1$) indicates that the plant is:
(A) A susceptible host allowing nematode multiplication
(B) A completely immune plant
(C) A completely resistant plant
(D) A completely non-host plant

2005

233. In resistance screening, a plant that suffers severe yield reduction but restricts nematode reproduction ($Rf < 1$) is termed:
(A) Intolerant resistant
(B) A tolerant plant
(C) A susceptible plant
(D) An immune plant

2006

234. A plant that supports high nematode reproduction ($Rf > 1$) but shows little or no yield reduction is termed:
(A) A tolerant plant
(B) A susceptible plant species
(C) A resistant plant species
(D) An immune plant species

NODIA

2001

235. Which nematode is associated with "red ring disease" in coconut and oil palms?
(A) Radopholus similis
(B) Bursaphelenchus cocophilus
(C) Aphelenchoides
(D) Pratylenchus

2010

236. How is the red ring nematode (Bursaphelenchus cocophilus) primarily transmitted from palm to palm?
(A) By the South American palm weevil
(B) Through the soil and by way of root grafts
(C) Wind-blown rain
(D) Through the use of infected palm seeds

2010

237. The pine wood nematode, Bursaphelenchus xylophilus, causes catastrophic wilt in pine forests. It is vectored by:
(A) Monochamus species (Pine sawyer beetles)
(B) Bark beetles

(C) Aphids
(D) Leafhoppers

2018

238. What is the typical life cycle duration of Meloidogyne incognita under optimal environmental conditions (25-30°C)?
(A) 21-30 days
(B) 3-5 days
(C) 60-90 days
(D) 1 year

2006

239. The structure responsible for guiding the spicules during copulation in male nematodes is the:
(A) Gubernaculum
(B) Bursa
(C) Cloaca
(D) Telamon

2004

240. Select the correct sequence of events during a typical nematode molting process:
(A) Apoplysis → Epicuticle formation → Ecdysis
(B) Ecdysis → Apoplysis → Epicuticle formation
(C) Epicuticle formation → Ecdysis → Apoplysis
(D) Apoplysis → Ecdysis → Epicuticle formation

2012

241. What is "apoplysis" in the context of nematode molting?
(A) Separation of old cuticle from the hypodermis
(B) The actual shedding of the previous old cuticle
(C) The synthesis of various new cuticular proteins
(D) The hardening of the newly formed cuticle

2007

242. The term "syncytium" is best defined as:
(A) A large multinucleate cell formed by cell wall fusion
(B) A single, large cell containing only one massive nucleus
(C) A mass of very rapidly dividing host cells
(D) A completely hollowed-out and dead root cell

2019

243. The pharyngeal (esophageal) glands of plant-parasitic nematodes secrete effectors into the host plant primarily through the:
(A) Stylet
(B) Excretory pore
(C) Amphids
(D) Cuticle

2015

244. Nematode "effectors" are molecules that:
(A) Alter host metabolism, suppress defenses, and help parasitism
(B) Break down the soil matrix
(C) Digest the nematode's own cuticle during the molting process
(D) Protect the nematode egg from various fungal attacks

2001

245. One of the pioneering discoveries in nematology was the horizontal gene transfer of cellulase genes. These genes likely originated from:
(A) Bacteria
(B) Viruses
(C) Fungi
(D) Host plants

2015

246. What is the role of nematode-secreted cellulases and pectate lyases?
(A) Digest host cell walls during penetration and migration
(B) To synthesize the entire protective cyst wall
(C) To detoxify all the various plant defense chemicals
(D) To break down starch into glucose for metabolic energy

2013

247. The chorion of a nematode egg is comprised primarily of:
(A) Chitin
(B) Cellulose
(C) Peptidoglycan
(D) Lignin

2015

248. The inner-most layer of the nematode eggshell, which is crucial for preventing desiccation and regulating permeability, is the:
(A) Lipid layer
(B) Vitelline layer
(C) Chitinous layer
(D) Proteinaceous layer

2005

249. Which of the following defines a "nurse cell" system?
(A) Host cells modified by the nematode to supply nutrients
(B) Cells that function to transport water to the leaves
(C) Nematode cells that secrete various digestive enzymes

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(D) Plant cells that undergo apoptosis to stop the infection

2009

250. Arrange the following plant-parasitic nematode genera in order of their feeding classification: Migratory ectoparasite, Migratory endoparasite, Sedentary endoparasite.
(A) Pratylenchus → Trichodorus → Meloidogyne
(B) Trichodorus → Pratylenchus → Meloidogyne
(C) Meloidogyne → Pratylenchus → Trichodorus
(D) Trichodorus → Meloidogyne → Pratylenchus

2001

251. Which environmental factor heavily influences sex determination in Meloidogyne species?
(A) Host nutritional status and crowding factors
(B) Average light intensity
(C) Soil texture type
(D) Atmospheric carbon dioxide levels

2010

252. Under conditions of severe crowding or poor host nutrition, Meloidogyne populations will typically develop into:
(A) A high proportion of males
(B) Exclusively females
(C) Hermaphrodites
(D) Only J3 stages

2017

253. The occurrence of males in Meloidogyne incognita populations indicates:
(A) Environmental stress, with reproduction staying parthenogenetic
(B) Presence of optimal growing conditions
(C) The beginning of the actual sexual reproduction phase
(D) A random mutation in the population

2016

254. Pathotypes in nematodes are populations of a given species that are distinguished by their ability to:
(A) Multiply on specific resistant crop cultivars
(B) Reproduce at different temperatures
(C) Survive in different soil types
(D) Produce different types of symptoms on the same host

2013

255. The concept of "physiological races" is heavily documented in which important nematode species affecting global agriculture?
(A) Meloidogyne incognita
(B) Radopholus similis
(C) Hirschmanniella oryzae
(D) Aphelenchoides besseyi

NODIA

2007

256. The North Carolina Differential Host Test is used to identify:
(A) Races of Meloidogyne incognita and M. arenaria
(B) Genera of entomopathogenic nematodes
(C) Pathotypes of Globodera rostochiensis
(D) Biotypes of Tylenchulus semipenetrans

2015

257. Which crops are included in the standard North Carolina Differential Host Test?
(A) Tobacco, Cotton, Pepper, Watermelon, Peanut, Tomato
(B) Wheat, Barley, Oats, Rye
(C) Potato, Tomato, Eggplant
(D) Citrus, Banana, Black Pepper

2008

258. Meloidogyne incognita Race 1 is distinguished from Race 3 by its inability to reproduce on:
(A) Cotton (cv. Deltapine)
(B) Tomato
(C) Tobacco (cv. NC95)
(D) Peanut

2004

259. What is a "concomitant infection"?
(A) Simultaneous infection of a host by two or more species
(B) Infection by a single species at multiple sites on the root
(C) Sequential infection where one nematode simply follows another
(D) Infection limited to the root cortex

2014

260. During concomitant infection, antagonistic interactions between different nematode species often occur due to:
(A) Competition for feeding sites and space
(B) Direct predation
(C) Production of nematicidal toxins by one species against another
(D) Cross-mating leading to sterile offspring

2019

261. In root-knot nematode infected tissues, the expression of genes involved in the plant cell cycle is heavily manipulated, leading to:
(A) Endoreduplication
(B) Arrest in G1 phase
(C) Immediate apoptosis

(D) Complete cessation of DNA synthesis

2021

262. "Endoreduplication" in giant cells results in:
(A) Cells with multiplied DNA content and large, lobed nuclei
(B) The formation of multiple small and distinct cells
(C) Very rapid and localized cell division
(D) Noticeable thinning of the host cell wall

2009

263. The cell walls of giant cells possess specialized ingrowths that increase surface area for solute transport. These are similar to structures found in:
(A) Transfer cells
(B) Guard cells
(C) Xylem vessels
(D) Sieve tube elements

2003

264. What morphological alteration is characteristic of roots heavily infected by Belonolaimus longicaudatus (sting nematode)?
(A) Severe necrosis and "stubby root" appearance
(B) Enormous galls
(C) Yellowing of the root tip
(D) Proliferation of fine root hairs

2022

265. Belonolaimus longicaudatus is primarily problematic in which type of soils?
(A) Sandy soils
(B) Heavy clay soils
(C) Muck soils
(D) Loamy soils

2012

266. Which class of chemicals is typically considered a contact nematicide?
(A) Fosthiazate
(B) Methyl bromide
(C) 1,3-Dichloropropene
(D) Fluopyram

2001

267. 1,3-Dichloropropene (1,3-D) functions primarily as a:
(A) Soil fumigant
(B) Systemic nematicide
(C) Contact nematicide
(D) Biological control agent

2014

268. Soil conditions such as moisture and temperature are critical when applying fumigants because:
(A) Volatilization and diffusion in soil are required for efficacy
(B) The fumigants only work during the night
(C) High moisture acts to destroy the chemical instantly
(D) Low temperatures cause the chemical to explode suddenly

2014

269. The phenomenon of "enhanced biodegradation" refers to:
(A) Rapid breakdown of a nematicide by adapted soil microbes
(B) Nematodes rapidly mutating in order to survive nematicides
(C) Plants taking up the nematicide and neutralizing it quickly
(D) Sunlight breaking down the chemical on the soil surface level

2011

270. Enhanced biodegradation was a major factor in the loss of efficacy of which nematicide?
(A) Fenamiphos
(B) Methyl bromide
(C) Neem oil
(D) Formaldehyde

2017

271. What does the term "suppressive soil" mean in nematology?
(A) Soil where disease is suppressed by beneficial microflora
(B) A soil type that physically acts to crush nematodes
(C) A soil treated with excessive amounts of various fumigants
(D) A soil lacking oxygen

2022

272. Cereal cyst nematode (Heterodera avenae) decline in monoculture wheat fields in Europe was largely attributed to parasitism by which fungi?
(A) Nematophthora gynophila and Verticillium chlamydosporium
(B) Trichoderma and Aspergillus
(C) Rhizoctonia and Pythium
(D) Fusarium and Alternaria

2021

273. Nematophthora gynophila targets which specific stage of the cyst nematode?
(A) Developing females before they form protective cysts
(B) Migrating J2 in the soil

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(C) Adult males
(D) Eggs within the mature cyst

2003

274. In plant nematology, what does "tolerance" refer to?
(A) The plant's ability to yield well despite nematode reproduction
(B) The plant's inherent ability to kill the nematode
(C) The plant's level of resistance to nematicidal chemicals
(D) The plant completely preventing all nematode penetration

2016

275. Breeding for nematode resistance is often complicated by linkage drag. What is linkage drag?
(A) Transfer of undesirable traits linked to the resistance gene
(B) The direct physical attachment of nematodes to the root
(C) The gradual loss of resistance in higher temperatures
(D) The very rapid movement of nematodes through the xylem

2018

276. What innovative molecular technique is increasingly used to silence essential nematode genes by feeding the nematode transgenic plant material?
(A) HIGS via RNA interference
(B) CRISPR-Cas9
(C) Standard Agrobacterium-mediated transformation
(D) TILLING

2002

277. In an RNAi approach against nematodes, the transgenic plant expresses:
(A) dsRNA homologous to a target nematode gene
(B) A lethal neurotoxin
(C) High levels of chitinase
(D) A range of specific nematicidal antibodies

2003

278. Which root-knot nematode species is generally adapted to cooler climates and is a major pest of vegetables in temperate regions?
(A) Meloidogyne hapla
(B) Meloidogyne javanica
(C) Meloidogyne arenaria
(D) Meloidogyne incognita

2014

279. Meloidogyne hapla can be morphologically distinguished by its perineal pattern, which features:
(A) Punctations in the tail terminal area above the anus
(B) Presence of a high and squarish dorsal arch
(C) The presence of distinct lateral incisures
(D) Possession of a complete lack of striae

2003

280. What causes the distinct "forked" or heavily branched root symptoms commonly seen on carrots infected by Meloidogyne hapla?
(A) Destruction of the primary root apical meristem
(B) The production of a specific toxin that splits the root
(C) The nematode laying eggs deep inside the vascular cylinder
(D) Concomitant infection with specific Agrobacterium

2001

281. The cyst nematode Heterodera zeae is an important pest of which crop in India?
(A) Maize
(B) Wheat
(C) Rice
(D) Sugarcane

2005

282. Which of the following defines the term "polyphagous" as applied to many root-knot nematodes?
(A) They possess multiple stylets
(B) They have a wide host range spanning many plant families
(C) They feed on many multiple parts of the same plant species
(D) They consume various soil bacteria along with plant sap

NODIA

2023

283. Heterodera schachtii was historically important for being the first plant-parasitic nematode targeted for management using which cultural practice?
(A) Trap cropping
(B) Flooding
(C) Intercropping
(D) Soil solarization

2021

284. Who developed the first method of trap cropping to manage the sugarbeet cyst nematode?

(A) Julius Kuhn
(B) Hermann Schacht
(C) N. A. Cobb
(D) H. C. Bastian

2005

285. In integrated pest management, what is the role of a "non-host" crop in a rotation scheme?
(A) It starves obligate nematodes, reducing the population
(B) It effectively attracts and traps the nematodes
(C) It releases various lethal fumigants into the soil
(D) It physically prevents all nematode movement in the soil

2003

286. Radopholus similis isolates that only attack banana and not citrus are referred to as the:
(A) Banana biotype
(B) Citrus biotype
(C) Universal biotype
(D) Root-knot biotype

2011

287. Which feature prevents the effective use of crop rotation against Radopholus similis in banana plantations?
(A) Banana is perennial, making rotation difficult
(B) The nematode's ability to survive in soil for 10 years without a host
(C) The nematode attacks all of the known cover crops
(D) The nematode lives and stays entirely above ground

2006

288. Hirschmanniella species possess a characteristic small projection at the tip of their tail called a:
(A) Mucro
(B) Phasmid
(C) Spicule
(D) Spinneret

2004

289. The condition known as "mentum" or having the lip region set off by a distinct constriction is a morphological feature of:
(A) Hoplolaimus
(B) Tylenchorhynchus
(C) Aphelenchoides
(D) Criconemoides

2002

290. Nematodes belonging to the family Criconematidae are easily recognized by their:
(A) Prominent, thick cuticle giving a ringed appearance
(B) Possession of a smooth, transparent cuticle
(C) Possession of extremely long tails
(D) Possession of a complete lack of a stylet

2014

291. Macroposthonia and Criconemella are genera commonly known as:
(A) Ring nematodes
(B) Pin nematodes
(C) Lance nematodes
(D) Dagger nematodes

2023

292. Ring nematodes move very sluggishly due to their thick cuticle and typically feed as:
(A) Ectoparasites
(B) Migratory endoparasites
(C) Sedentary endoparasites
(D) Predators

2025

293. The extraction technique known as the "centrifugation-flotation method" commonly utilizes a high-density solution of which chemical to float nematodes?
(A) Sodium chloride or sucrose
(B) Ethanol
(C) Formalin
(D) Acetone

2011

294. What is the primary advantage of the centrifugation-flotation extraction method over the Baermann funnel?
(A) Extracts active and inactive nematodes from soil
(B) It is much cheaper and requires no equipment
(C) It only extracts eggs
(D) It keeps the nematodes alive for many months

2014

295. Which type of microscope is fundamentally required for detailed taxonomic identification of plant-parasitic nematodes?
(A) High-resolution compound microscope with DIC
(B) Use of a simple dissecting microscope
(C) A scanning electron microscope (SEM) primarily
(D) Use of a fluorescence microscope

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2008

296. The "Oostenbrink elutriator" is a piece of equipment used to separate nematodes from soil based on differences in:
(A) Sinking velocities in upward water currents
(B) Specific chemical affinity
(C) Attraction to specific wavelengths of light
(D) The resistance to high temperatures

2024

297. Which of the following is considered an environmentally friendly, plant-derived nematicidal product commercially available?
(A) Bionematicides based on Azadirachtin (Neem)
(B) Carbofuran
(C) Methyl bromide
(D) Ethoprop

2005

298. To ensure the safe movement of agricultural commodities, treating plant materials (like bulbs or corms) with hot water requires precise temperature control. What is a typical effective temperature range for hot water treatment to kill internal nematodes without damaging the plant tissue?
(A) 30-35°C
(B) 50-55°C
(C) 70-75°C
(D) 90-100°C

2001

299. In nematode-infected plants, above-ground symptoms such as chlorosis and wilting are considered:
(A) Secondary symptoms from impaired root function
(B) Direct symptoms of active feeding
(C) The symptoms of systemic viral infection
(D) Actual proof of foliar nematode infection

2025

300. Which integrated management approach relies on combining host resistance, crop rotation, and judicious use of bionematicides to keep nematode populations below the economic threshold level?
(A) Integrated Nematode Management (INM)
(B) Eradication
(C) Exclusion
(D) Total chemical sterilization

NODIA

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ANSWERS

1. (A) Turbevill Needham
The discovery of the first plant-parasitic nematode occurred in 1743 when Turbevill Needham observed small, fiber-like organisms inside wheat galls. This foundational event marked the beginning of agricultural nematology. Needham identified the causal agent of ear cockle disease in wheat, providing the earliest documented evidence that microscopic nematodes could significantly impact important crop yields in global agricultural systems.

2. (C) N. A. Cobb
Nathan Augustus Cobb is widely regarded as the father of modern nematology due to his extensive work in the early 20th century. He established many fundamental techniques for sampling, extracting, and describing these organisms. His publication of comprehensive manuals and standardized morphological measurements created a robust taxonomic framework that remains essential for researchers studying plant-parasitic species in agricultural environments.

3. (A) Discovered the sugarbeet cyst nematode
In 1859, Hermann Schacht made a significant contribution to the field by discovering the sugarbeet cyst nematode in Germany. This discovery was critical because it identified the cause of beet tiredness, a major agricultural problem at the time. His work laid the foundation for the study of cyst-forming nematodes, which are now recognized as some of the most destructive pests.

4. (D) First reported root-knot nematode galls on cucumber
Miles Joseph Berkeley is historically recognized for reporting the first known occurrence of root-knot nematode galls on cucumber in 1855. This observation was pivotal in identifying the damage caused by the genus Meloidogyne. His work highlighted how these microscopic organisms induce morphological changes in host roots, significantly affecting plant health and leading to the eventual recognition of their economic importance.

5. (B) He discovered the first virus-vector nematode
Julius Kuhn was a major figure in early nematology, notably pioneering soil fumigation using carbon basisulphide and describing several important species. While he made significant advances in controlling the sugarbeet cyst nematode and identifying stem and bulb nematodes, he did not discover the first virus-vector nematode. That specific milestone was achieved much later in the middle of the twentieth century.

6. (C) B. G. Chitwood
Benjamin Goodwin Chitwood established the basic morphological and anatomical framework of nematodes during the mid-20th century. His seminal work, An Introduction to Nematology, published in 1937, organized the existing knowledge of nematode structure into a scientific system. This contribution was vital for the development of modern nematode taxonomy and remains a standard reference for students and professional researchers.

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7. (D) C. A. Barber
The first report of a plant-parasitic nematode in India was made by C. A. Barber in 1901. He discovered the presence of root-knot nematodes on tea plants in South India. This finding was significant as it marked the formal beginning of agricultural nematology in the country, leading to increased awareness of the impact of these pests on plantation crops.

8. (A) Described the Ufra disease of rice
Edwin John Butler made a major contribution to Indian agricultural nematology by describing the Ufra disease of rice in 1913. He correctly identified the foliar nematode Ditylenchus angustus as the causative agent. This discovery was crucial for understanding yield losses in deep-water rice systems and established a precedent for the study of nematode-induced plant diseases in tropical agriculture.

9. (B) Root-knot nematode on cotton
P. N. Krishna Ayyar's early work in India was primarily associated with the discovery of root-knot nematodes affecting cotton crops in the

1920s and 1930s. His research identified the genus Meloidogyne as a significant threat to cotton production. This work was important for establishing the host range of these parasites and highlighting their impact on diverse industrial crops in India.

10. (A) Both A and R are true and R is the correct explanation of A.
Nathan Augustus Cobb contributed significantly to the fields of nematode taxonomy and morphology by introducing precise scientific methods. He developed a standardized formula for nematode measurements, known as the Cobb formula, which provides a numerical representation of body proportions. This quantitative approach revolutionized the classification process, allowing researchers to distinguish between similar species using objective and highly reproducible morphological data.

11. (A) A. R. Seshadri
A. R. Seshadri played a pivotal role in establishing the Division of Nematology at the Indian Agricultural Research Institute in New Delhi in 1966. His leadership was essential for the formalization of nematological research and education in India. Under his guidance, the division became a center for training and research, significantly advancing the understanding and management of nematode pests.

12. (B) 10-14%
Current estimates suggest that plant-parasitic nematodes account for a global crop yield reduction of approximately ten to fourteen percent annually. This economic burden is particularly severe in developing nations where intensive agriculture and warm climates favor nematode reproduction. These losses often go unnoticed because the above-ground symptoms resemble nutrient deficiencies, leading to significant underestimation of their actual global agricultural impact.

13. (D) They survive adverse conditions and spread easily via soil or plant material
The quarantine significance of plant-parasitic nematodes arises from their ability to survive adverse environmental conditions and spread easily through contaminated soil, water, or plant materials. Many species can enter states of dormancy or form protective structures like cysts. Their microscopic size makes detection difficult, facilitating their accidental movement across international borders and posing a threat to global agricultural biosecurity.

14. (C) Comparing yields between nematicide-treated and untreated plots
The primary method used to estimate crop yield losses caused by nematodes in the field involves comparing harvests from nematicide-treated plots with untreated ones. This paired-plot technique allows researchers to isolate the impact of nematode damage from other environmental factors. By measuring the yield difference, scientists can quantify the economic damage and determine the necessity of implementing specific management strategies.

15. (B) Soil-borne nature makes nematode eradication virtually impossible
Nematodes are notoriously difficult to manage because their soil-borne nature makes total eradication virtually impossible once they are established. They inhabit complex soil environments and can survive at varying depths, protected by the soil matrix. While management practices can suppress populations to levels below the economic threshold, the persistence of these organisms ensures they remain a continuous threat to agricultural production.

16. (D) Cuticle
The cuticle is the outermost covering of a plant-parasitic nematode, serving as a protective barrier against environmental stress and host defenses. This non-cellular layer is highly complex and periodically shed during the molting process as the nematode grows. It also functions as an exoskeleton, providing the structural support necessary for the nematode's characteristic sinusoidal movement through the soil and plant tissues.

17. (B) Four
In a typical nematode, the hypodermis forms four longitudinal chords that bulge into the body cavity. These chords are located at the dorsal, ventral, and two lateral positions. They contain the nuclei of the hypodermal cells and house the primary longitudinal nerve cords. The lateral chords are often the most prominent and are frequently used as diagnostic features in taxonomic studies.

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18. (C) Stylet
The stylet is an essential diagnostic feature that differentiates plant-parasitic nematodes from most free-living species. This sclerotized, hollow, needle-like structure is used to pierce plant cell walls and inject digestive enzymes. It also serves as a tube for withdrawing nutrients from the host cells. The presence, size, and shape of the stylet are critical for the classification of plant parasites.

19. (A) The intestine is lined with a rigid cuticle that sheds during molting
The digestive system of plant-parasitic nematodes includes a stoma, esophagus, intestine, and rectum. While the stoma, esophagus, and rectum are lined with cuticle that is shed during molting, the intestine is not. The intestine is a non-cuticularized tube where nutrient absorption occurs. It consists of a single layer of epithelial cells and serves as the primary site for metabolic processes.

20. (A) P-4, Q-3, R-2, S-1
In the male reproductive system, spicules serve as the primary intromittent organs during copulation, while the gubernaculum acts as a sclerotized guide for their movement. The bursa is a specialized flap of cuticle used to grasp the female. Conversely, the spermatheca is a female structure designed to store sperm, ensuring fertilization occurs efficiently within the reproductive tract during development.

21. (A) Basal bulb
The basal bulb, or terminal bulb, of the nematode esophagus contains the dorsal and subventral gland cells. These glands produce various enzymes and effectors that are essential for the processes of host penetration and feeding. The secretions are transported through ducts to the esophageal lumen, where they facilitate the digestion of plant tissues and help the nematode manipulate host cell metabolism.

22. (D) Cloaca
In the male nematode reproductive system, the vas deferens opens into the cloaca, which is a common chamber for both the digestive and reproductive tracts. The cloaca also houses the spicules and associated structures used for mating. This anatomical arrangement allows for the discharge of both sperm and waste products through a single posterior opening, which is a characteristic feature of males.

23. (A) Parthenogenesis
Parthenogenesis is a reproductive strategy where unfertilized eggs develop into viable offspring without the requirement for male participation. This phenomenon is common in many plant-parasitic nematode species, such as those in the genus Meloidogyne. This ability allows populations to increase rapidly even in the absence of males or under stressful environmental conditions, facilitating the efficient colonization of new host plants.

24. (C) Four
The life cycle of a typical plant-parasitic nematode consists of four distinct juvenile stages, conventionally labeled J1 through J4. Each stage is separated by a molting event, during which the old cuticle is shed and a new one is formed. After the final molt from the fourth juvenile stage, the nematode reaches the adult stage, where it becomes sexually mature and reproductive.

25. (B) Ecdysis
Ecdysis is the physiological process of shedding the old cuticle during the transition from one juvenile stage to the next. This phenomenon is essential for nematode growth, as the rigid cuticle must be replaced to accommodate the increasing size of the organism. Molting involves the synthesis of a new cuticle beneath the old one, followed by the rupture and shedding of the previous layer.

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26. (D) J2
In most plant-parasitic nematodes, the second-stage juvenile is the stage that typically hatches from the egg. This stage is often the infective stage, responsible for locating and penetrating the host plant roots. The transition from the first juvenile stage to the second stage usually occurs within the eggshell, ensuring the nematode is sufficiently developed to survive the soil environment upon hatching.

27. (D) Inside the egg
The first molt from the J1 to the J2 stage usually occurs inside the egg in most plant-parasitic nematode species. This internal developmental step ensures that the nematode is in its infective stage before it hatches into the soil. By completing the first molt within the protective

eggshell, the nematode increases its chances of successfully locating a host and initiating the infection process.

28. (A) Xiphinema
The genus Xiphinema, commonly known as dagger nematodes, is an exception to the general rule because the first-stage juvenile hatches from the egg. Unlike most other plant-parasitic nematodes that hatch as J2, Xiphinema species begin their free-living life in the soil at an earlier stage. This developmental difference is a significant characteristic used in the taxonomic and biological study of these organisms.

29. (B) Cleavage of the zygote
Embryogenesis in nematodes begins with the cleavage of the zygote immediately after fertilization or the initiation of parthenogenesis. This process involves a series of rapid cell divisions that lead to the formation of the blastula and gastrula stages. These early developmental steps are essential for the organization of tissues and the eventual formation of the vermiform juvenile stage within the eggshell.

30. (A) I and II
Molting is a complex physiological process that occurs four times during the nematode's development to adulthood. It involves the synthesis of a new cuticle by the hypodermis followed by the partial or complete shedding of the old cuticle. This recurring event is necessary for growth, as the previous cuticle is too rigid to allow for the increase in body size required during maturation.

31. (D) Ectoparasites
Ectoparasitic nematodes feed on the outer layers of the host root without completely entering the tissue. They typically remain in the soil and use their long stylets to reach and penetrate the epidermal or cortical cells of the root. This feeding behavior causes damage to the root surface and can lead to symptoms like stunting or the cessation of root tip growth.

32. (D) Pratylenchus penetrans
Pratylenchus penetrans, commonly known as the lesion nematode, is a classic example of a migratory endoparasite. Both juveniles and adults enter the root tissue and move continuously through the cortex while feeding. This migration causes extensive cell destruction, leading to the formation of necrotic lesions. Their ability to move between the soil and roots allows them to colonize new areas of the plant.

33. (A) Establishing a permanent feeding site inside the root
Sedentary endoparasites are characterized by their behavior of establishing a permanent feeding site within the host root. Once the infective juvenile penetrates the root and reaches a suitable location, it becomes stationary and induces the formation of specialized feeding cells. The nematode then undergoes further development, losing its vermiform shape and remaining at that single site for the remainder of its life.

34. (D) Semi-endoparasite
Rotylenchulus reniformis is classified as a semi-endoparasite because only the anterior portion of the female's body penetrates the host root. The posterior part of the body remains outside the root and swells into a kidney shape as the nematode matures. This intermediate feeding strategy allows the nematode to feed on internal vascular tissues while maintaining a presence in the surrounding soil environment.

35. (A) Chlorosis and stunting
Chlorosis and stunting are typical above-ground symptoms of a severe root nematode infection. Because nematodes damage the root system and disrupt the uptake of water and nutrients, the plant often exhibits signs of deficiency. These symptoms are frequently confused with nutrient shortages or drought stress, as the affected plants appear pale, yellow, and significantly smaller than healthy individuals in the same field.

36. (D) Criconemoides
The genus Criconemoides, known as ring nematodes, is characterized by a thick, heavily annulated cuticle that gives the body a ringed appearance. These nematodes move very slowly and exhibit a sluggish behavior compared to other species. Their unique morphology and feeding habits as ectoparasites make them a distinct group within the order Tylenchida, often found in woody plants and turfgrasses.

37. (D) Pratylenchus
Root lesions are necrotic areas on the root surface primarily caused by the invasion and movement of the genus Pratylenchus. As these migratory

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endoparasites feed and travel through the root cortex, they destroy plant cells, creating wounds. These necrotic areas often turn dark brown or black, reducing the root's functional capacity and providing entry points for various soil-borne pathogens.

38. (A) Meloidogyne
The genus Meloidogyne is well known for inducing the formation of distinctive root galls or knots on host plants. When the infective juveniles enter the root and establish feeding sites, they cause the surrounding cells to enlarge and divide abnormally. This localized swelling results in visible galls, which disrupt the vascular system and significantly impair the plant's ability to transport water.

39. (B) Globodera - Cysts on roots
Globodera species are characterized by the formation of cysts on the roots of host plants. After the female matures and dies, her body wall hardens into a protective, spherical cyst that encases the eggs. These cysts are often visible to the naked eye as small, white, yellow, or brown grains attached to the root surface, serving as a key diagnostic feature.

40. (C) I and IV
Meloidogyne species are sedentary endoparasites, not migratory ones, as they establish a permanent feeding site. While the infective J2 is vermiform, the adult females become saccate or pear-shaped as they mature. Therefore, the statements suggesting they are migratory and that females remain vermiform are incorrect. They are known for inducing giant cells and utilizing the J2 as the infective life stage.

41. (C) Serve as nutrient sinks for the developing nematode
Giant cells induced by root-knot nematodes function as essential nutrient sinks for the developing parasite. These specialized cells are metabolically active and highly enlarged, concentrating nutrients transported from other parts of the plant. By manipulating host cell processes, the nematode ensures a constant and rich supply of food, which is necessary for its rapid growth and high reproductive output.

42. (D) By repeated mitosis without cytokinesis
Giant cells in Meloidogyne infections typically form through the process of repeated mitosis without cytokinesis. When the nematode initiates feeding, it triggers the host cell to undergo nuclear division, but the cell does not split into two. This results in a single, massive, multinucleate cell with high metabolic activity, which provides the sedentary nematode with a concentrated source of nutrition.

43. (A) Meloidogyne tritici
While Meloidogyne incognita, Meloidogyne javanica, and Meloidogyne arenaria are major root-knot nematode species affecting many agricultural crops globally, Meloidogyne tritici is not recognized as a major pest in this group. Most significant damage to cereal crops by root-knot nematodes is caused by other species, such as Meloidogyne graminicola, which is specifically adapted to rice and other related grasses.

44. (D) Perineal pattern
The perineal pattern is the most important morphological feature used for species identification in adult female Meloidogyne. This pattern is located in the posterior region around the vulva and anus and consists of characteristic cuticular ridges or striae. The specific arrangement, height, and shape of these ridges vary between species, providing a reliable diagnostic tool for nematologists using high-power microscopy.

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45. (B) Purpureocillium lilacinum
Purpureocillium lilacinum, formerly known as Paecilomyces lilacinus, is a frequently utilized biological control agent in integrated management of root-knot nematodes. This fungus specializes in parasitizing nematode eggs, effectively reducing the soil population before hatching occurs. By penetrating the eggshell and consuming the developing embryo, it provides a sustainable and environmentally friendly method for suppressing nematode damage in various agricultural crops.

46. (D) Developing a lemon-shaped body that forms a hard cyst
The adult female of Heterodera species is distinguished by its lemon-shaped body, which eventually hardens to form a protective cyst. As the female matures, her body swells and her cuticle thickens and tans, turning into a durable structure that protects the eggs from environmental stress and predation. This cyst

can persist in the soil for many years, serving as a survival mechanism.

47. (A) Syncytia
Heterodera species induce the formation of a specialized feeding structure known as a syncytium within the host root. This multinucleate structure is formed by the dissolution of cell walls and the subsequent fusion of adjacent protoplasts. The syncytium acts as a highly efficient nutrient source for the sedentary nematode, allowing it to complete its life cycle and produce hundreds of eggs.

48. (B) Cell wall dissolution and fusion of neighboring protoplasts
Syncytia induced by cyst nematodes are formed through cell wall dissolution and the subsequent fusion of neighboring protoplasts. This process creates a single, continuous multinucleate mass from many pre-existing cells. This is different from the formation of giant cells in Meloidogyne, which result from repeated nuclear division within a single cell. Both structures serve as specialized nutrient sinks for the parasite.

49. (A) Wheat
Heterodera avenae, commonly known as the cereal cyst nematode, is an economically important pest that primarily infects wheat and barley. In India, it causes the devastating molya disease, which is characterized by severe stunting and reduced grain production. The nematode's ability to form persistent cysts in the soil makes it a difficult pest to manage in traditional cereal-growing regions.

50. (A) Both A and R are true and R is the correct explanation of A.
Cyst nematodes are highly persistent because the dead body of the mature female hardens into a protective cyst. This durable structure encases the eggs, shielding them from environmental extremes and biological threats in the soil. Consequently, the eggs can remain viable for many years even in the absence of a host plant, which explains the long-term survival of these nematode populations.

51. (A) Pigeonpea
Heterodera cajani, known as the pigeonpea cyst nematode, is a major constraint in the production of pigeonpea and other leguminous crops in India. It infects the root system, causing significant reductions in plant vigor and yield. The formation of cysts allows the nematode to survive between cropping seasons, making it a persistent challenge for pulse farmers in tropical and subtropical regions.

52. (D) Heterodera glycines
Heterodera glycines, the soybean cyst nematode, is globally recognized as one of the most devastating pests of soybean. It causes massive yield losses by disrupting root function and nutrient uptake. This species is highly adaptable and has multiple races that can overcome host resistance. Its ability to spread through soil movement and contaminated equipment makes it a major threat to soybean production.

53. (B) Crop rotation with non-host crops
Crop rotation with non-host crops is the most effective cultural practice for managing the soybean cyst nematode. By planting crops that the nematode cannot parasitize, the soil population is naturally reduced as the eggs hatch and the juveniles die from starvation. Long-term rotation strategies are essential because the cysts can survive for several years, requiring consistent management to maintain low populations.

54. (D) Potato cyst nematodes
Globodera rostochiensis and Globodera pallida are collectively known as potato cyst nematodes. These species are highly regulated quarantine pests that cause severe damage to potato crops worldwide. They are characterized by their spherical cysts, which distinguish them from the lemon-shaped cysts of the genus Heterodera. Their ability to persist in the soil makes them a significant challenge for potato production and international trade.

55. (B) Nilgiri and Palani hills
In India, the distribution of potato cyst nematodes is predominantly restricted to the high-altitude regions of the Nilgiri and Palani hills in Tamil Nadu. The cool climate of these areas is favorable for the development and survival of Globodera species. Because of their quarantine status, strict regulations are in place to prevent the movement of soil and tubers from these regions.

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56. (D) Globodera cysts are spherical, lacking a terminal cone
Globodera cysts are characteristically spherical and lack the distinct terminal cone found in Heterodera cysts. This morphological difference is a primary diagnostic feature used to separate the two genera. While Heterodera cysts are often described as lemon-shaped, Globodera cysts are round, reflecting the different body shapes of the mature females. This distinction is crucial for accurate pest identification and management.

57. (D) Breeding for resistant varieties
The existence of different pathotypes in Globodera species significantly complicates the breeding of resistant varieties. A variety that is resistant to one pathotype may be completely susceptible to another. Consequently, breeders must continuously identify and incorporate diverse resistance genes to address the variability within nematode populations. This ongoing process is necessary to provide farmers with effective tools for managing these persistent pests.

58. (B) Destructive Insects and Pests (DIP) Act
Domestic quarantine regulations in India are strictly enforced under the Destructive Insects and Pests Act of 1914. This legislation empowers authorities to regulate the movement of plant materials and soil to prevent the spread of serious pests like the potato cyst nematode. These measures are vital for protecting non-infested potato-growing regions and maintaining the integrity of the national agricultural economy.

59. (A) Exudates from potato roots
The hatching of Globodera eggs in the soil is primarily stimulated by chemical signals known as exudates released from the roots of potato plants. This specialized hatching response ensures that the infective juveniles emerge only when a suitable host is present. These root diffusates contain specific compounds that break the dormancy of the eggs, facilitating the synchronized infection of the host crop.

60. (A) I and IV
Pratylenchus species are migratory endoparasites, not sedentary ones, as they move continuously through the root tissue while feeding. They do not feed exclusively on root hairs; instead, they invade the root cortex, causing significant damage and necrotic lesions. While they have a wide host range and all stages can infect roots, the statements regarding sedentary behavior and root hair feeding are incorrect.

61. (A) Cortex
Pathogenesis by Pratylenchus species involves extensive tissue damage primarily within the root cortex. As these migratory endoparasites move and feed, they secrete enzymes that break down cell walls, leading to cell death and the formation of characteristic necrotic lesions. This destruction of cortical tissue reduces the root's ability to absorb water and nutrients, significantly impacting the overall health of the plant.

62. (B) Pratylenchus coffeae
Pratylenchus coffeae is a particularly damaging species of lesion nematode that affects coffee production globally. It invades the roots, causing extensive necrosis and leading to the decline and eventual death of the trees. The management of this pest is a major challenge in coffee plantations, often requiring the use of resistant rootstocks and clean planting material to minimize the economic impact.

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63. (D) Creating wounds that serve as entry points for fungi and bacteria
Lesion nematodes facilitate secondary infections in host plants by creating wounds as they migrate and feed within the root tissue. these openings serve as ideal entry points for various soil-borne fungi and bacteria that might not otherwise be able to penetrate the intact root. This synergistic interaction often results in more severe disease complexes, leading to rapid root rot and plant death.

64. (D) Toppling disease
Radopholus similis is the primary causal agent of toppling disease in bananas. As the nematodes destroy the root system and the rhizome, the plant's structural anchorage is severely weakened. This often leads to the entire banana plant falling over, especially under the weight of the developing fruit or during periods of high wind, resulting in a total loss of the crop.

65. (A) Citrus
The term spreading decline is associated with Radopholus similis infection in citrus trees. This disease is characterized by a slow reduction in tree vigor, smaller leaves, and a significant decrease

in fruit production. The nematode population gradually spreads through the orchard soil, causing a characteristic pattern of declining tree health that moves outward from the initial site of infestation.

66. (D) Slow decline (Pepper yellows)
The disease complex known as slow decline or pepper yellows in black pepper is heavily exacerbated by the presence of Radopholus similis. The nematode damages the root system, which impairs the uptake of water and nutrients, leading to the characteristic yellowing of the foliage and a gradual reduction in yield. This condition is a major factor limiting black pepper production in several regions.

67. (D) It has a degenerate stylet and does not feed
A key biological feature of the adult male Radopholus similis is that it possesses a degenerate stylet and does not engage in feeding. The males are primarily involved in reproduction and do not contribute to the direct damage of the host root tissue. This is in contrast to the females and juveniles, which are active feeders and responsible for the pathogenesis.

68. (A) Migratory endoparasite
Radopholus similis belongs to the group of migratory endoparasites, meaning that all life stages except the egg are mobile and feed within the host root tissue. They move through the roots, causing extensive cell destruction and necrotic cavities. This behavior allows them to multiply rapidly and move between different parts of the root system or into the surrounding soil to find new hosts.

69. (A) Paring and hot water treating corms
Paring and hot water treatment of corms is a highly recommended method for obtaining nematode-free banana planting material. Paring involves removing the infected outer layers of the rhizome, while hot water treatment at specific temperatures kills any remaining nematodes within the tissue. These practices are essential for preventing the introduction of Radopholus similis and other pests into new banana plantations.

70. (C) P-3, Q-4, R-1, S-2
Plant diseases are often linked to specific nematode species based on the unique symptoms they induce during infection. For instance, Radopholus similis causes toppling disease in bananas, while Heterodera avenae is responsible for molya disease in cereals. Similarly, Meloidogyne species induce root galls, and Tylenchulus semipenetrans is the primary agent behind the slow decline observed in citrus orchards worldwide.

71. (D) Flooded rice systems
Hirschmanniella species are widely recognized as major pests of flooded rice systems. These nematodes are uniquely adapted to aquatic environments and can survive and thrive in submerged soils. They are particularly destructive in irrigated and lowland rice fields, where they invade the roots and cause significant reductions in plant growth and yield by interfering with the efficient transport of vital nutrients.

72. (D) Hirschmanniella oryzae
Hirschmanniella oryzae is commonly referred to as the rice root nematode and is one of the most widespread pests in rice-growing regions. It is a migratory endoparasite that feeds and multiplies within the cortex of rice roots. The resulting damage leads to stunted growth and reduced tillering, which can cause substantial economic losses in both traditional and modern rice production systems.

73. (B) In roots of self-sown rice and weed hosts
Hirschmanniella oryzae primarily survives during the off-season in rice fields by inhabiting the roots of self-sown rice plants and various weed hosts. This ability to maintain populations on alternative plants ensures that the nematodes are present to infect the next rice crop. Effective weed management is therefore a critical component of integrated strategies for controlling this specific nematode in rice ecosystems.

74. (B) All juvenile stages and adults
In the genus Hirschmanniella, all juvenile stages and adults are capable of infecting rice roots. They are migratory endoparasites that can enter and leave the root tissue at various points throughout their life cycle. This continuous ability to infect and cause damage makes them persistent pests, as the entire population remains active and destructive as long as suitable host roots are available.

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75. (A) Reniform nematode
The genus Rotylenchulus is commonly known as the reniform nematode, a name derived from the kidney-shaped body of the mature female. These nematodes are important pests of a wide range of crops, including cotton, soybean, and various vegetables. Their unique life cycle and semi-endoparasitic feeding behavior make them a distinct group that requires specific management approaches in diverse agricultural systems.

76. (B) Kidney-shaped
The mature female of Rotylenchulus reniformis exhibits a distinctive kidney shape, which is the origin of its common name. As the female reaches maturity and establishes a permanent feeding site, her posterior body swells and curls, while her anterior portion remains embedded within the root. This characteristic morphology is a primary diagnostic feature used to identify the species during root examinations.

77. (C) Females become kidney-shaped; males stay slender and non-feeding
Rotylenchulus reniformis exhibits significant sexual dimorphism, where the females become kidney-shaped upon maturation while the males remain slender and vermiform. Furthermore, the adult males do not feed, as they possess a degenerate stylet. This differentiation reflects their distinct roles, with the females being responsible for parasitism and egg production, while the males are primarily focused on the fertilization process.

78. (D) In the soil without feeding
In the life cycle of the reniform nematode, the molts from the second juvenile stage to the pre-adult immature female typically occur in the soil without feeding. This unique developmental pattern means that the nematode does not require a host to complete these intermediate stages. The immature female is the stage that eventually seeks out and penetrates the host root to initiate feeding.

79. (B) Immature female
The immature female is the infective stage of Rotylenchulus reniformis. After completing several molts in the soil without feeding, the slender, vermiform immature female locates a host root and penetrates the cortex to establish a feeding site. Once established, she begins to swell into the characteristic kidney shape and starts producing eggs, completing the parasitic phase of her life cycle.

80. (A) Both A and R are true and R is the correct explanation of A.
The reniform nematode is classified as a semi-endoparasite because only the anterior portion of the female's body penetrates the host root tissue. The posterior part remains outside the root, swelling into a characteristic kidney shape as the nematode matures. This feeding strategy allows the nematode to establish a permanent feeding site while maintaining exposure to the surrounding soil environment during reproduction.

81. (C) Slow decline of citrus
Tylenchulus semipenetrans is the primary causative agent of the slow decline of citrus trees. This disease is characterized by a gradual loss of tree vigor, reduced leaf size, and a significant decrease in the quantity and quality of fruit. The nematode's semi-endoparasitic feeding behavior causes chronic damage to the root system, which leads to the characteristic symptoms observed in many citrus orchards.

82. (A) J2 female
The J2 female of the citrus nematode is the life stage responsible for establishing the permanent feeding site. Upon hatching, the motile J2 female locates a suitable root and penetrates the outer layers with its anterior end. Once the feeding site is established, the nematode becomes sedentary and undergoes further development, eventually maturing into the characteristic swollen female that produces eggs.

83. (A) Nurse cells
The feeding site of Tylenchulus semipenetrans consists of a specialized group of modified plant cells known as nurse cells. These cells are induced by the nematode to become highly metabolically active and serve as a concentrated source of nutrients. The formation of nurse cells is essential for the growth and reproduction of the sedentary female, as they provide all the necessary sustenance.

84. (A) It swells and protrudes from the root surface
As the mature female Tylenchulus semipenetrans feeds, her posterior body swells and protrudes from the root surface into the surrounding soil. This part of the body is responsible for producing

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a gelatinous matrix into which the eggs are laid. The protruding body and the associated egg sac often collect soil particles, giving the infected roots a characteristic dirty or gritty appearance.

85. (B) Ability to parasitize and reproduce on different indicator hosts (e.g., Poncirus trifoliata, olive)
The existence of biotypes in Tylenchulus semipenetrans is determined by their ability to parasitize and reproduce on specific indicator hosts. Different populations may show varying levels of virulence on plants like Poncirus trifoliata or olive. Identifying these biotypes is crucial for selecting appropriate resistant rootstocks, as a rootstock that is resistant to one biotype might be susceptible to another in the field.

86. (C) Ditylenchus
The genus Ditylenchus includes the stem and bulb nematodes, which are important pests of many agricultural and ornamental plants. Unlike many other plant-parasitic nematodes, these species primarily target the above-ground parts of the plant, such as stems, leaves, and bulbs. Their ability to cause significant tissue distortion and survive in a desiccated state makes them a major concern for global crop protection.

87. (B) Above-ground stems, leaves, and bulbs
Ditylenchus dipsaci primarily affects the above-ground stems, leaves, and bulbs of its host plants. It is an endoparasite that moves through the internal tissues, using pectinase enzymes to dissolve the middle lamellae between cells. This activity causes the tissue to swell and become distorted, leading to characteristic symptoms like bloating, twisting, and the breakdown of structural integrity in many affected crops.

88. (B) Entering a state of anhydrobiosis
The principal survival mechanism of Ditylenchus dipsaci under desiccating conditions is entering a state of anhydrobiosis. In this state, the nematode loses most of its body water and becomes metabolically inactive, allowing it to survive extreme drought and high temperatures for many years. Once water becomes available, the nematode rehydrates and resumes its normal activity, facilitating its persistence in the environment.

89. (B) Ditylenchus dipsaci
The term nematode wool refers to the aggregated, desiccated masses of Ditylenchus dipsaci that can be found on the surface of infected plant material or in the soil. These masses consist of thousands of individuals in a state of anhydrobiosis, appearing as a white, cottony substance. This survival strategy protects the nematodes from environmental stress and allows them to be easily dispersed by wind or water.

90. (B) III and IV
Ditylenchus dipsaci produces pectinase enzymes that dissolve the middle lamellae of host cells, facilitating its movement through the plant. This enzymatic activity leads to the characteristic swelling and distortion of stems and leaves. While it is a significant pest of above-ground tissues, it is not an obligate root parasite and does not possess an exceptionally robust stylet compared to other species.

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91. (C) Ear cockle disease
Anguina tritici is the nematode responsible for causing ear cockle disease in wheat. This disease is characterized by the replacement of healthy grains with dark, hard galls containing thousands of dormant second-stage juveniles. The presence of these galls reduces the quality and yield of the harvest. Effective management traditionally involves seed cleaning and crop rotation to prevent the reintroduction of the parasite.

92. (A) J2
The infective stage of Anguina tritici that emerges from the seed gall is the second-stage juvenile. These juveniles are highly resistant to desiccation and can remain dormant within the gall for many years. When the gall is moistened in the soil, the J2 emerge and migrate to the growing point of the wheat plant, where they eventually enter the developing flower buds.

93. (B) Rathayibacter tritici
Anguina tritici serves as a vector for the pathogenic bacterium Rathayibacter tritici, which causes yellow ear rot, also known as tundu disease, in wheat. The bacteria attach to the cuticle of the nematode and are carried to the floral tissues. This association leads to the production of a characteristic yellow, sticky slime on the wheat head, resulting in the total loss of grain.

94. (B) Floating the seeds in a 20% brine solution
The most practical and traditional method for separating Anguina tritici galls from healthy wheat seeds is floating them in a 20% brine solution. Because the galls are lighter than healthy seeds, they float to the surface and can be easily skimmed off and destroyed. This simple but effective technique is a critical step in managing ear cockle disease in several traditional farming communities.

95. (A) Aphelenchoides
The genus Aphelenchoides consists of nematodes that are primarily characterized as foliar nematodes. They infect the leaves, stems, and flower buds of many plant species, including rice and various ornamental plants. Their ability to move in films of water and feed on both fungal and plant tissues makes them versatile pests. Foliar symptoms often include angular leaf spots and stunted terminal growth.

96. (C) White tip disease
Aphelenchoides besseyi is the causal agent of the significant white tip disease in rice. This disease is characterized by the whitening and drying of the leaf tips, which often become twisted or curled. The nematode is seed-borne and survives in a desiccated state within the grain. Upon planting, it migrates to the growing tissues, eventually affecting the panicle and reducing the overall grain yield.

97. (B) By migrating up the stem in a film of water
Aphelenchoides besseyi disseminates to the upper parts of the rice plant by migrating up the stem within a thin film of water. This movement often occurs during periods of high humidity, rain, or heavy dew. By using capillary action and its own motility, the nematode can reach the developing foliage and panicles, where it initiates feeding and reproduction, leading to the characteristic disease symptoms.

98. (B) Hot water treatment at 52-54°C for 15 minutes
Hot water treatment at 52 to 54 degrees Celsius for 15 minutes is highly effective in eradicating Aphelenchoides besseyi from rice seeds. This precise temperature range is sufficient to kill the nematodes without significantly affecting the germination of the seeds. This method is a critical management practice for preventing the spread of white tip disease through contaminated seed lots in rice production systems.

99. (B) Floriculture (ornamental plants like Chrysanthemum)
Aside from rice, Aphelenchoides species are notoriously devastating to the floriculture industry, particularly affecting ornamental plants like Chrysanthemum. They cause angular leaf spots, where the necrotic areas are bounded by the leaf veins. This damage not only reduces the health of the plant but also significantly decreases its aesthetic and commercial value, making foliar nematodes a major concern for greenhouse and nursery growers.

100. (A) Both A and R are true and R is the correct explanation of A.
Aphelenchoides species possess a well-developed metacorpus that occupies most of the body width, which is a diagnostic feature of the order Aphelenchida. This muscular structure functions as a powerful pump for ingesting food and injecting digestive enzymes. The size and shape of the metacorpus are essential characteristics used by taxonomists to distinguish these nematodes from members of other orders, such as Tylenchida.

101. (A) Stunt nematodes
Tylenchorhynchus species are commonly referred to as stunt nematodes. This name reflects the primary symptom they cause in host plants, which is a significant reduction in overall growth and height. These nematodes are migratory ectoparasites that feed on the epidermal cells of the roots. Their feeding activity impairs root function, leading to the characteristic stunted appearance and general lack of vigor in infected crops.

102. (B) Migratory ectoparasite
Tylenchorhynchus species exhibit a migratory ectoparasitic feeding behavior. They remain in the soil throughout their life cycle and move between different feeding sites on the root surface. By using their stylets to penetrate the outer root cells, they extract nutrients without entering the tissue. This continuous movement and feeding can lead to widespread damage to the root system, particularly in various grasses and field crops.

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103. (C) General reduction in the root system and severe stunting of the plant
The primary crop impact of stunt nematodes is best described by a general reduction in the size of the root system and severe stunting of the entire plant. Because they feed on the roots, they interfere with the efficient uptake of water and nutrients. The affected plants are often pale and exhibit poor growth, leading to significant yield losses in heavily infested agricultural fields.

104. (C) Their habit of curling into a spiral shape when relaxed or dead
Helicotylenchus species derive their common name, spiral nematodes, from their habit of curling into a characteristic spiral shape when they are relaxed or dead. This morphological behavior is a key diagnostic feature used during the identification of these nematodes in soil samples. While they are active in the soil, they are important pests of many plants, often causing small necrotic lesions on the roots.

105. (B) Banana
Helicotylenchus multicinctus is a major pest of banana crops worldwide. It is a migratory endoparasite that invades the outer layers of the banana roots and rhizomes, causing small, reddish-brown lesions. This damage weakens the root system and can lead to reduced plant vigor and lower fruit yields. Managing this nematode is essential for maintaining the health and productivity of many commercial banana plantations.

106. (C) Lance nematodes
Hoplolaimus species are robust nematodes commonly known as lance nematodes. This name refers to their relatively large and strong stylet, which they use to penetrate deep into the root tissues. They are important pests of many field crops, such as cotton, corn, and sugarcane. Their feeding activity causes significant damage to the root cortex and vascular tissues, leading to severe stunting and yield loss.

107. (B) A heavily sclerotized cephalic framework
A distinct morphological feature of Hoplolaimus species is a heavily sclerotized cephalic framework in the head region. This robust internal structure provides support for the powerful muscles used to operate their large stylet. The presence of this thickened framework is a critical diagnostic characteristic used by taxonomists to identify the genus during microscopic examinations of soil and plant tissue samples.

108. (A) Dry rot of yam tubers
Scutellonema species are commonly known as yam nematodes because they cause a condition known as dry rot in yam tubers. These nematodes invade the tubers and feed on the internal tissues, leading to the formation of dark, necrotic areas. This damage not only reduces the quality and yield of the yams but also facilitates the entry of various secondary decay-causing organisms.

109. (B) Enlarged phasmids called scutella at the tail region
The genus Scutellonema is characterized by specialized morphological features known as scutella, which are greatly enlarged phasmids located in the tail region. These structures are visible under a microscope and serve as a primary diagnostic tool for identifying the genus. The presence of these large, disk-like sensory organs distinguishes Scutellonema from related genera like Helicotylenchus, which have much smaller phasmids.

110. (B) Pin nematodes
Paratylenchus species are commonly referred to as pin nematodes due to their small body size and relatively long, thin stylet. These nematodes are migratory ectoparasites that feed on the roots of a wide range of plants, including fruit trees and various vegetables. Despite their small size, they can reach very high population densities in the soil, leading to significant reductions in plant growth.

111. (A) Possess an unusually long stylet relative to small body size
Adult female Paratylenchus are characterized by possessing an unusually long stylet relative to their small overall body size. This morphological adaptation allows these tiny nematodes to feed on cells deep within the root tissue while remaining on the outside. This feature is a key diagnostic characteristic used to identify the genus and distinguish it from other small, root-feeding nematodes in soil samples.

112. (B) II only
Entomopathogenic nematodes in the genera Steinernema and Heterorhabditis are beneficial organisms that parasitize insects, not plant roots. They have a mutualistic association with

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specific bacteria that help kill the insect host. The infective juvenile is the only stage found in the soil, and they are known for their ability to kill insects within a very short period, typically 24 to 48 hours.

113. (A) Infective Juvenile (IJ) or J3
The specialized stage of entomopathogenic nematodes that survives in the soil and seeks out insect hosts is the infective juvenile, also known as the IJ or the third juvenile stage. This stage is uniquely adapted for environmental persistence and host-finding. Once a suitable host is located, the IJ enters the insect and initiates the infection process, carrying its symbiotic bacteria into the host's body.

114. (A) Ambushing
Ambushing is a foraging strategy where the infective juvenile stands on its tail in a behavior called nictation, waiting to attach to a passing insect. This strategy is typical of nematodes that target highly mobile insects on the soil surface. By remaining stationary and waiting for the host to come to them, these nematodes conserve energy while maximizing their chances of successful infection.

115. (A) Ambushing
Steinernema carpocapsae is considered a classic example of an entomopathogenic nematode that utilizes an ambushing host-finding strategy. Its infective juveniles often stay near the soil surface and engage in nictation to wait for mobile insect hosts. This behavior makes them particularly effective against pests like caterpillars that move across the soil, providing a targeted method of biological control in various agricultural systems.

116. (B) Cruising
Heterorhabditis bacteriophora typically utilizes a cruising host-finding strategy to locate sedentary insects deep in the soil. The infective juveniles are highly mobile and actively move through the soil matrix, responding to chemical signals and carbon dioxide released by potential hosts. This active searching behavior allows them to find and infect insect larvae, such as white grubs, that reside in subterranean environments.

117. (C) Through natural openings such as the mouth, anus, or spiracles
Infective juveniles of entomopathogenic nematodes typically enter the insect host through natural openings such as the mouth, anus, or spiracles. Some species, particularly those in the genus Heterorhabditis, also possess a small dorsal tooth that allows them to penetrate the thinner parts of the insect's cuticle. Once inside, the nematodes move into the hemocoel, where they release their symbiotic bacteria to kill the host.

118. (A) J2 cuticle
Entomopathogenic nematode infective juveniles retain the cuticle from the previous J2 stage as a protective sheath. This second cuticle provides an extra layer of defense against environmental stresses, such as desiccation and microbial attack, while the nematode is in the soil. This adaptation is crucial for their long-term survival and persistence in the environment until a suitable insect host is eventually located.

119. (B) It releases its mutualistic symbiotic bacteria
Once inside the insect hemocoel, the entomopathogenic nematode infective juvenile performs the critical action of releasing its mutualistic symbiotic bacteria. These bacteria are carried in the nematode's intestine and are expelled into the insect's blood. The bacteria multiply rapidly, producing toxins that kill the insect and antibiotics that prevent other microbes from colonizing the cadaver, creating a suitable environment for nematode reproduction.

120. (A) P-2, Q-1
Specific genera of entomopathogenic nematodes are associated with specific genera of symbiotic bacteria. Nematodes in the genus Steinernema carry bacteria of the genus Xenorhabdus, while nematodes in the genus Heterorhabditis are associated with Photorhabdus bacteria. This mutualistic relationship is highly specialized, with the bacteria providing nutrients and protection for the nematodes, while the nematodes serve as vectors for the bacteria.

121. (B) Causing fatal septicemia and releasing toxins
The symbiotic bacteria associated with entomopathogenic nematodes cause rapid insect mortality primarily by causing fatal septicemia and releasing potent toxins. Once released into the insect hemocoel, the bacteria multiply exponentially, overwhelming the host's immune system. The combination of bacterial growth and the production of specialized insecticidal

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compounds ensures that the host dies within 24 to 48 hours, providing a rich food source.

122. (A) Convert host tissues into a suitable food source for the nematodes
Besides killing the insect, the symbiotic bacteria serve the crucial function of converting the host's internal tissues into a suitable food source for the nematodes. They produce various enzymes that break down the insect's proteins and lipids into simpler nutrients that the nematodes can easily ingest. This process ensures that the nematodes have a concentrated and abundant supply of nutrition for their development.

123. (D) They are bioluminescent
Photorhabdus bacteria, which are associated with Heterorhabditis nematodes, possess the unique characteristic of being bioluminescent. In the dark, insect cadavers infected with these nematodes and their bacteria may emit a faint glow. This phenomenon is a result of the bacteria's metabolic activity and is a distinctive feature of this genus. It can sometimes be used as a diagnostic indicator of Heterorhabditis infection in the field.

124. (B) Carried in a specialized intestinal vesicle of infective juveniles
Symbiotic bacteria are transmitted from one generation of entomopathogenic nematodes to the next by being carried in a specialized intestinal vesicle of the infective juveniles. As the nematodes develop within the insect cadaver, the new IJs incorporate the bacteria before they emerge into the soil. This ensures that every infective juvenile is equipped with the necessary partner to successfully infect and kill its next host.

125. (A) Hermaphroditism
A unique reproductive mechanism in the first generation of Heterorhabditis inside the insect host is hermaphroditism. The infective juvenile develops into a self-fertilizing hermaphroditic adult, which allows a single nematode to initiate a large population within the host. Subsequent generations typically consist of both males and females that reproduce through amphimixis. This strategy maximizes the reproductive potential of each successful infection event.

126. (B) Galleria mellonella (Greater wax moth)
In vivo mass multiplication of entomopathogenic nematodes is most commonly conducted using the larvae of the greater wax moth, Galleria mellonella. These larvae are highly susceptible to nematode infection and provide a large, nutrient-rich environment for nematode reproduction. They are also relatively easy and inexpensive to rear in the laboratory, making them the standard host for small-scale production and research purposes.

127. (B) White trap method
The White trap method is the most common technique used to harvest entomopathogenic nematode infective juveniles from insect cadavers during in vivo production. This setup involves placing the infected cadavers on a raised platform surrounded by water. As the nematodes mature and emerge from the cadavers, they migrate into the water, where they can be easily collected and concentrated for further use or formulation.

128. (C) In vitro liquid fermentation in bioreactors
For commercial-scale application, entomopathogenic nematodes are typically produced via in vitro liquid fermentation in large bioreactors. This method allows for the production of massive quantities of nematodes in a controlled environment using artificial growth media. Liquid fermentation is more efficient and scalable than in vivo methods, making it the preferred choice for manufacturing commercial nematode-based biological control products worldwide.

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129. (C) The specific symbiotic bacteria
During in vitro liquid fermentation of entomopathogenic nematodes, the specific symbiotic bacteria must be cultured in the bioreactor before the nematodes are introduced. This step is essential because the nematodes depend on the bacteria to provide the necessary nutrients and to create a suitable environment for their growth and reproduction. Once the bacteria reach an optimal density, the nematodes are inoculated to begin the production cycle.

130. (C) I and III
Entomopathogenic nematodes can be formulated in various carriers to maintain their viability and facilitate application. Common formulations include alginate gel capsules, water-dispersible granules, and sponges. However, they cannot be

completely desiccated to a dry powder, as they require a certain level of moisture to survive. These formulations are designed to protect the nematodes from environmental stress during storage and field distribution.

131. (A) Ultraviolet (UV) radiation from direct sunlight
Ultraviolet radiation from direct sunlight is highly lethal to the infective juveniles of entomopathogenic nematodes. When these beneficial organisms are exposed to UV rays on the soil surface, their survival rate drops precipitously within minutes. Consequently, successful field application requires strategies to minimize solar exposure, such as applying treatments during low-light periods to ensure the nematodes reach the protective soil environment.

132. (B) Early morning or late evening
To maximize the efficacy of entomopathogenic nematodes in the field, the best time to apply them is during the early morning or late evening. These periods provide lower temperatures and higher humidity, which help prevent the nematodes from drying out. Additionally, the lack of direct sunlight reduces the harmful effects of ultraviolet radiation, ensuring more nematodes survive to locate and infect their insect targets.

133. (B) Standard agricultural sprayers with filters removed
Standard agricultural sprayers can be used to apply entomopathogenic nematodes as a liquid suspension to the soil, provided the filters and fine nozzles are removed to prevent clogging and physical damage to the nematodes. Using moderate pressure is important to ensure the organisms remain viable. This practical approach allows farmers to use existing equipment to integrate biological control into their pest management programs.

134. (A) Symbiotic bacteria produce factors suppressing the insect immune system
Entomopathogenic nematodes avoid host immune responses primarily because their symbiotic bacteria produce specialized factors that suppress the insect's immunity. These factors can inhibit hemocyte activity and prevent the encapsulation of the nematode. By neutralizing the host's defenses, the bacteria and nematodes can multiply freely, ensuring the rapid death of the insect and providing a secure environment for the parasite's development.

135. (B) Bacteria switching between primary and secondary phenotypic variants
Phase variation in entomopathogenic nematode symbiotic bacteria refers to their ability to switch between primary and secondary phenotypic variants. The primary phase is characterized by its ability to support nematode reproduction and produce antibiotics and pigments. The secondary phase often lacks these qualities and may occur under stressful conditions. Managing these phases is critical for maintaining the quality and efficacy of commercial nematode production.

136. (B) Supports nematode reproduction better and produces antibiotics
The primary phase of Xenorhabdus or Photorhabdus is preferred in mass production because it supports nematode reproduction much more effectively than the secondary phase. Additionally, primary phase bacteria produce antibiotics that suppress the growth of competing microbes within the insect cadaver or bioreactor. This ensures a clean and nutrient-rich environment that maximizes the yield of high-quality infective juveniles for biological control.

137. (A) Karl Rudolphi
Karl Rudolphi was a foundational figure in helminthology who established the basic taxonomy of nematodes and separated them from other groups of worms in the early 19th century. His work provided one of the first systematic classifications of these organisms, which were previously grouped haphazardly. This organization was essential for the subsequent development of nematology as a distinct scientific discipline focusing on these unique animals.

138. (A) A stomatostylet
The classical order Tylenchida is characterized by the presence of a stomatostylet, which is a hollow, sclerotized feeding spear. The stomatostylet is derived from the lining of the stoma and typically features three basal knobs for muscle attachment. This structure is a primary diagnostic feature of the order and is essential for the parasitic lifestyle of many significant plant-parasitic nematode species.

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139. (A) Xiphinema
The genus Xiphinema, commonly known as dagger nematodes, is well known for its ability to transmit nepoviruses. These viruses are carried on the lining of the nematode's esophagus and are transmitted to the host plant during the feeding process. Because they affect a wide range of fruit crops and ornamentals, managing Xiphinema populations is critical for controlling the spread of these economically damaging viruses.

140. (B) III only
While Longidorus and Trichodorus are well-known vectors of nepoviruses and tobraviruses respectively, the genus Meloidogyne is not known to transmit potyviruses. Virus particles in vector nematodes are typically retained in the stylet or the lining of the esophagus and are introduced into the host during feeding. Understanding these relationships is essential for managing the spread of plant viral diseases in various agricultural systems.

141. (B) Odontostylet
The stylet of Longidorus and Xiphinema is structurally derived from a tooth and is called an odontostylet. This structure is characteristic of the order Dorylaimida and differs from the stomatostylet found in Tylenchida. The odontostylet is often exceptionally long, allowing these nematodes to feed on cells deep within the root tissues, even from the outside of the root as migratory ectoparasites.

142. (A) Onchiostylet
Nematodes in the order Triplonchida, such as Trichodorus, possess a solid, curved feeding spear known as an onchiostylet. Unlike the hollow stylets of other plant-parasitic nematodes, the onchiostylet is used to puncture cell walls, after which the nematode ingests the escaping contents. This unique feeding mechanism is a key diagnostic feature of the stubby-root nematodes, which are also known vectors of tobraviruses.

143. (D) Trichodorus
Trichodorus species, known as stubby-root nematodes, feed near the root tip, causing it to stop growing. This feeding activity results in a characteristic stubby appearance, where the roots are short and thickened with multiple branches. By damaging the meristematic tissue, these nematodes severely impair the development of the entire root system, leading to significant stunting and reduced water uptake in many crops.

144. (A) Three-part (corpus, isthmus, basal bulb)
The order Tylenchida is characterized by a three-part esophagus consisting of an anterior corpus, a narrow isthmus, and a posterior basal bulb. The corpus often contains a muscular median bulb that acts as a pump for ingesting nutrients. This complex esophageal structure is highly efficient for the parasitic lifestyle, allowing the nematode to inject enzymes and withdraw sap from the host plant cells.

145. (A) Slender anterior and expanded posteriorly
In the order Dorylaimida, the esophagus is typically slender in the anterior portion and becomes expanded posteriorly. This dorylaimoid esophagus lacks the distinct median bulb found in Tylenchida. The expanded posterior part contains the esophageal glands and is responsible for producing the enzymes needed for feeding. This anatomical arrangement is a defining characteristic used to identify members of this diverse group of soil nematodes.

146. (D) Tylenchorhynchus brevilineatus
Tylenchorhynchus brevilineatus is the nematode responsible for causing the Kalahasti malady in groundnut. This disease was first identified in the Kalahasti region of India and is characterized by the appearance of brownish-black lesions on the pods and roots. The nematode's feeding activity reduces the quality and yield of the groundnut, making it a major concern for farmers in the affected areas.

147. (A) Andhra Pradesh
Tylenchorhynchus brevilineatus causes severe stunting and pod discoloration in groundnut specifically in the state of Andhra Pradesh, India. The disease, known as Kalahasti malady, is highly localized but can cause significant economic damage in infested fields. Understanding the distribution and biology of this stunt nematode is essential for implementing targeted management practices to protect groundnut production in the southeastern regions of the country.

148. (A) Summer deep ploughing
Summer deep ploughing is considered one of the most effective management practices against the cereal cyst nematode, Heterodera avenae. By turning the soil over during the hot summer

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months, the cysts and eggs are exposed to lethal temperatures and intense solar radiation. This physical treatment significantly reduces the viable soil population, providing a sustainable and low-cost method for protecting wheat and barley crops.

149. (C) Heterodera avenae
The molya disease of wheat and barley in Rajasthan, India, is caused by the cereal cyst nematode, Heterodera avenae. This disease is characterized by patchy growth, severe stunting, and reduced grain formation in infected fields. The nematode forms persistent cysts that survive in the soil between seasons. It is one of the most economically damaging nematode pests in the cereal-growing regions of northern India.

150. (C) A is true but R is false.
Plant-parasitic nematodes possess a specialized feeding structure called a stylet, which is used to pierce plant cell walls and withdraw nutrients. However, the stylet is primarily a feeding organ, not a defensive structure used against predatory nematodes. While it is essential for the parasitic lifestyle, its anatomical design and function are optimized for accessing the internal contents of plant cells rather than for combat.

151. (A) Aphelenchoides besseyi
Aphelenchoides besseyi, the rice white tip nematode, causes the pecky rice symptom by feeding on developing rice grains within the panicle. This feeding activity leads to the discoloration and distortion of the kernels, significantly reducing the market value and quality of the rice. Because the nematode is seed-borne, it can easily spread through contaminated grain lots if not properly managed.

152. (A) Ufra disease
Ditylenchus angustus is the causal organism of the devastating Ufra disease in deep-water rice. This foliar nematode infects the young leaves and panicles, leading to severe twisting and crinkling of the tissues. In many areas, Ufra can cause total crop failure, as the plants fail to produce viable grain. Its ability to survive in rice stubble makes it a persistent challenge in flooded ecosystems.

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153. (C) Stunted growth with crinkled and twisted panicles
A key symptom of Ufra disease in rice is stunted growth accompanied by crinkled and twisted panicles. The infection by Ditylenchus angustus disrupts the normal development of the reproductive tissues, often preventing the panicles from emerging fully from the leaf sheath. This results in significant yield losses, as the grains that do form are often shriveled or completely sterile.

154. (B) In anhydrobiosis on crop residues
Ditylenchus angustus survives the dry season between rice crops by entering a state of anhydrobiosis on crop residues and rice stubble. In this desiccated condition, the nematode can withstand environmental extremes until the return of the monsoon rains. This survival strategy ensures that a viable population is present to infect the next season's rice crop as soon as water becomes available.

155. (C) Meloidogyne graminicola
Meloidogyne graminicola, the rice root-knot nematode, is particularly problematic in upland and rainfed lowland rice ecosystems. Unlike many other root-knot nematodes, it is specifically adapted to grasses and can survive flooded conditions. It causes significant damage to the root system, reducing nutrient uptake and tillering, which leads to substantial yield losses in diverse rice-growing environments across Asia and South America.

156. (A) Terminal, often hook-like galls on root tips
Unlike other root-knot nematodes that cause galls throughout the root system, the galls caused by Meloidogyne graminicola are typically located at the root tips. These terminal galls often take on a characteristic hook-like shape. This specific symptom is a primary diagnostic feature used to identify the rice root-knot nematode in the field, reflecting its preference for infecting young, active meristematic tissues.

157. (B) Well-drained upland or intermittently flooded soil
Damage by Meloidogyne graminicola is most severe in well-drained upland or intermittently flooded soils. These conditions allow the nematode to move and infect roots more efficiently compared to continuously flooded environments. Because the nematode is sensitive to prolonged

anaerobic conditions, its impact is often greater in rainfed systems where soil moisture levels fluctuate, providing favorable periods for the parasite's development and spread.

158. (B) Nematode invasion is restricted, reducing crop damage
When a rice field is deeply and continuously flooded, the invasion of Meloidogyne graminicola is significantly restricted, thereby reducing crop damage. The anaerobic conditions created by flooding are unfavorable for the nematode, which requires oxygen for its metabolic activities and movement. This cultural practice is an effective management strategy in irrigated rice systems, helping to suppress nematode populations and protect the crop.

159. (A) Meloidogyne
The genus Meloidogyne is known to have a mutualistic association with vesicular-arbuscular mycorrhizae, which can sometimes mitigate the damage caused by the nematodes. The presence of these beneficial fungi can improve the plant's nutrient and water uptake, compensating for the loss of root function caused by the galls. Understanding these microbial interactions is important for developing more resilient crop management systems.

160. (A) II, III and IV
Quiescence is an immediate and reversible response to unfavorable environmental conditions, and anhydrobiosis is a specific form of quiescence induced by desiccation. Cryptobiosis involves a complete but reversible cessation of metabolism, allowing nematodes to survive extreme stress. While diapause is an endogenous arrest of development, it is not always spontaneous. Furthermore, some nematodes are adapted to survive freezing temperatures, making those statements correct.

161. (B) Anhydrobiosis (desiccation)
Trehalose accumulation is a critical biochemical adaptation that helps nematodes survive anhydrobiosis, a state of extreme desiccation. This sugar acts as a stabilizer for proteins and cellular membranes, preventing damage during the loss and subsequent reacquisition of water. The ability to synthesize and store trehalose allows many plant-parasitic and free-living nematodes to persist in arid environments for extended periods.

162. (C) Auxin
Root-knot nematodes heavily manipulate the host's auxin hormone pathway to induce the formation of specialized giant cells. By altering local auxin levels and signaling, the nematode triggers abnormal cell growth and repeated nuclear divisions. This hormonal manipulation is essential for establishing the feeding site, ensuring a continuous supply of nutrients that are diverted from the plant's normal growth processes to the parasite.

163. (B) Protecting eggs from desiccation and microbial attack
The gelatinous matrix secreted by female Meloidogyne serves the primary purpose of protecting the eggs from desiccation and microbial attack in the soil. This matrix encases the eggs in a moisture-retaining and antimicrobial environment, significantly increasing their survival rate until they are ready to hatch. This adaptation is vital for the persistence of root-knot nematode populations across diverse environmental conditions.

164. (A) Rectal glands
In Meloidogyne species, the gelatinous matrix is secreted by specialized rectal glands located in the posterior region of the female. These six large glands produce the matrix, which is then expelled through the anus to form a protective sac around the eggs. This anatomical adaptation is a key feature of the genus, highlighting the specialized nature of their reproductive and survival strategies.

165. (A) Ventrally, near the nerve ring
In a typical plant-parasitic nematode, the excretory pore is located ventrally, usually near the level of the nerve ring in the esophageal region. This pore is the exit point for the tubular excretory system, which helps maintain the nematode's internal osmotic balance and remove waste. Its precise position is a useful morphological landmark for taxonomists during the identification of various nematode species.

166. (D) Nerve ring
The central nervous system of a nematode consists primarily of a circumesophageal commissure, commonly known as the nerve ring. This structure surrounds the esophagus and serves as the main processing center for the nematode, connecting various longitudinal nerve

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cords. It coordinates sensory inputs from the head and tail, allowing the nematode to respond to environmental cues such as chemical gradients and physical contact.

167. (D) Laterally on the head (lip region)
Amphids are paired chemosensory organs located laterally on the head, specifically in the lip region of the nematode. They are essential for sensing chemical signals in the environment, such as root exudates from potential host plants. The size and shape of the amphidial openings are important taxonomic characters used to distinguish between different groups and species of nematodes.

168. (B) Tail region
Phasmids are specialized sensory organs located in the tail region of many nematodes, particularly those in the class Secernentea. They are thought to function as chemoreceptors or mechanoreceptors, helping the nematode navigate its environment. The presence, size, and location of the phasmids are critical diagnostic features used in the classification and identification of many important plant-parasitic nematode genera.

169. (D) Phasmids
Nematodes belonging to the class Adenophorea, also known as Enoplea, typically lack phasmids, which are sensory structures found in the tail region of the class Secernentea. Instead, they often possess other sensory structures, such as amphids that are usually more complex or located further back on the head. This fundamental difference is one of the primary criteria used to divide the phylum Nematoda into its major classes.

170. (A) P-4, Q-1, R-3, S-2
Basic nematode anatomy consists of specialized structures with distinct functions. The stylet is the primary feeding structure used to pierce plant cells. The median bulb acts as a muscular pump for ingesting nutrients. The nerve ring represents the central nervous system, coordinating movement and sensory input. Finally, spicules are male copulatory organs used during reproduction to facilitate the transfer of sperm.

171. (A) Tubular (H-shaped or inverted U-shaped)
The excretory system in Secernentea nematodes is typically tubular, often forming an H-shaped or inverted U-shaped structure. This system consists of canals that run along the lateral chords and connect to a ventral excretory pore. This anatomical arrangement is efficient for osmoregulation and waste removal in the diverse environments inhabited by these nematodes, serving as a defining characteristic of the class.

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172. (A) Tylenchida
The presence of a bursa, also known as caudal alae, is a distinguishing feature in the males of the order Tylenchida. This specialized cuticular structure consists of two lateral flaps that are used to grasp the female during copulation. The size and shape of the bursa, whether it surrounds the tail tip or is restricted to a specific area, are important taxonomic characters.

173. (B) Extraction via Cobb's decanting and sieving method
The primary method for estimating nematode population density in soil is extraction via Cobb's decanting and sieving method. This technique relies on the difference in size and density between nematodes and soil particles. By repeatedly washing the soil and passing the suspension through increasingly fine sieves, nematodes can be concentrated and collected for counting and identification under a microscope.

174. (A) Baermann funnel technique
The Baermann funnel technique is a common extraction method that relies on the active movement of nematodes. A soil or plant sample is placed on a filter in a water-filled funnel. Motile nematodes move through the filter and settle at the bottom of the funnel, where they can be collected. This method is effective for extracting vermiform stages but does not capture inactive stages.

175. (D) Cysts
The Fenwick can method is specifically designed for the extraction of nematode cysts from soil samples. This technique utilizes the fact that mature cysts are buoyant and can be separated from heavier soil particles using a continuous flow of water. The floating cysts are collected on a series of sieves, allowing for the quantification of persistent pests like the potato cyst nematode.

176. (B) Formalin-Acetic Acid (FAA) or TAF
Formalin-Acetic Acid or TAF is routinely used for killing and fixing nematodes prior to

mounting them on microscopic slides. These chemicals preserve the internal anatomy and external morphology of the nematodes, preventing decay and maintaining the integrity of diagnostic features. Proper fixation is a critical step in the preparation of high-quality specimens for taxonomic study and long-term storage in scientific collections.

177. (D) Acid fuchsin in lactophenol
Acid fuchsin in lactophenol is a common staining technique used to visualize nematodes inside plant roots. The roots are cleared and then boiled in the stain, which is selectively taken up by the nematode tissues. This process makes the nematodes appear bright red or pink against the cleared root tissue, allowing researchers to observe their location, developmental stage, and feeding sites.

178. (A) A nematicide kills nematodes; a nematistat inhibits them
The fundamental difference between a nematicide and a nematistat is their mode of action. A nematicide is a chemical that directly kills nematodes, leading to a rapid reduction in the population. In contrast, a nematistat does not kill the organisms but inhibits their activity, such as their ability to move, feed, or reproduce. Both types of chemicals are used in agricultural pest management.

179. (B) Carbamates
Carbofuran is a widely used chemical for nematode management that belongs to the carbamate class of pesticides. Like other carbamates, it acts as a neurotoxin by inhibiting the enzyme acetylcholinesterase in the nematode's nervous system. This interference leads to paralysis and death, making it an effective tool for controlling a broad range of plant-parasitic nematodes in various field and plantation crops.

180. (A) Egg → J1 → J2 → J3 → J4 → Adult
The typical life cycle of a plant-parasitic nematode follows a standardized sequence of stages beginning with the egg. After embryonic development, the first-stage juvenile forms inside the egg and molts into the second-stage juvenile. The J2 then hatches and undergoes three more molts to become a mature adult. Each stage is characterized by growth and physiological changes necessary for reaching reproductive maturity.

181. (A) Trapping solar energy to heat soil to lethal temperatures
Soil solarization is a non-chemical control method that works by trapping solar energy under clear plastic sheets to heat the soil to lethal temperatures. This process kills many soil-borne pests, including nematodes, by thermal inactivation. It is most effective in regions with high solar radiation and is often used as a pre-planting treatment to reduce nematode populations in the upper layers of the soil.

182. (A) Neem cake
Neem cake is a well-known organic amendment that possesses nematicidal properties due to the release of bioactive compounds like azadirachtin during its decomposition. These substances interfere with the nematode's growth and reproduction. Additionally, the addition of organic matter to the soil promotes the activity of natural enemies and improves overall soil health, making it an effective component of integrated nematode management.

183. (A) Planting a susceptible crop and destroying it before reproduction
Trap cropping involves planting a susceptible host crop to attract nematodes and then destroying it before the parasites can complete their life cycle and reproduce. This technique effectively removes large numbers of nematodes from the soil, as they are killed within the host tissues. To be successful, the timing of the crop destruction is critical to prevent the population from increasing further.

184. (A) Alpha-terthienyl
Marigolds are frequently used in crop rotations to suppress root-knot nematodes because their roots release a potent nematicidal compound called alpha-terthienyl. This sulfur-containing molecule is toxic to many nematode species upon contact or ingestion. By planting marigolds, farmers can naturally reduce the soil population of pests, providing a chemical-free alternative for managing nematode-related damage in subsequent susceptible crops.

185. (D) Obligate, endospore-forming bacterium
Pasteuria penetrans is a significant biological control agent that is classified as an obligate, endospore-forming bacterium. It is highly specialized, parasitizing only specific groups of nematodes, particularly the root-knot

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nematodes. The bacteria form durable endospores that can persist in the soil for long periods. Once a nematode host is available, the bacterium initiates a complex infection process that ultimately leads to host death.

186. (A) Endospores attach, germinate, and penetrate the body cavity
Pasteuria penetrans infects its nematode host through a process where the bacterial endospores in the soil attach to the nematode's cuticle. As the nematode enters a plant root, the spores germinate and penetrate the body wall to enter the hemocoel. The bacterium then multiplies and consumes the internal tissues, eventually filling the adult nematode with millions of new spores and preventing reproduction.

187. (D) Forming adhesive three-dimensional hyphal networks (traps)
Arthrobotrys oligospora is a well-known nematophagous fungus that captures nematodes using adhesive three-dimensional hyphal networks. These sticky traps are formed in response to the presence of nematodes in the soil. When a nematode crawls through the network, it becomes stuck, after which the fungus penetrates the cuticle and consumes the body contents. This predatory behavior makes it a valuable biological control agent.

188. (B) Purpureocillium lilacinum
Purpureocillium lilacinum is a fungus specifically recognized as an egg parasite and is frequently used as a biological control agent against Meloidogyne and Heterodera. It is capable of surviving in various soil types and can be easily mass-produced for commercial use. By targeting the egg stage, this fungus effectively reduces the reproductive potential of nematode populations, providing long-term suppression of these agricultural pests.

189. (C) Hyphae penetrate the eggshell and consume the contents
Purpureocillium lilacinum parasitizes nematode eggs by extending fungal hyphae that physically penetrate the eggshell. Once inside, the fungus secretes enzymes to digest and consume the developing embryo or juvenile. This direct parasitism prevents the eggs from hatching, thereby reducing the initial inoculum in the soil. This mechanism is highly effective for managing sedentary nematodes that produce large, accessible egg masses in the rhizosphere.

190. (A) I, II, IV, III
The Baermann funnel extraction method follows a specific operational sequence to isolate motile nematodes. First, the sample is placed in a tissue paper-lined sieve, which is then put into a funnel. Water is added until it touches the bottom of the sample. After being left undisturbed for 24 to 48 hours to allow nematode migration, the suspension is collected from the funnel bottom.

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191. (A) Population density where management is economically justified
The economic threshold level in nematology refers to the nematode population density at which the cost of implementing management practices is equal to the value of the yield loss prevented. Identifying this threshold is essential for making informed pest management decisions. By only treating fields when the population exceeds this level, farmers can maximize their economic returns and minimize the unnecessary use of nematicides.

192. (A) Mi gene
The Mi gene is a critical resistance gene that was successfully introgressed into tomato from the wild species Solanum peruvianum. It confers resistance against the three most common species of root-knot nematodes: Meloidogyne incognita, Meloidogyne javanica, and Meloidogyne arenaria. This gene has been widely used in tomato breeding programs globally, providing a highly effective and sustainable method for controlling these destructive pests.

193. (B) High soil temperature (above 28°C)
The resistance provided by the Mi gene in tomato is known to break down under conditions of high soil temperature, typically above 28 degrees Celsius. At these elevated temperatures, the gene is no longer effective, and the plant becomes susceptible to root-knot nematode infection. This thermal sensitivity is a major limitation for using Mi-resistant varieties in tropical and subtropical regions where soil temperatures often exceed this threshold.

194. (A) Ro1
The H1 gene provides a high level of resistance in potato against the Ro1 pathotype of the golden cyst nematode, Globodera rostochiensis.

Originally derived from the wild potato species Solanum tuberosum ssp. andigena, this gene has been incorporated into many commercial potato cultivars. While highly effective against Ro1, it does not provide protection against other pathotypes or the related species Globodera pallida.

195. (A) Nematode-Fusarium wilt
The nematode-Fusarium wilt disease complex is a well-known synergistic interaction where the presence of root-knot nematodes significantly increases the severity of fungal wilt. The nematodes damage the root system and alter host physiology, facilitating the entry and spread of the fungus Fusarium oxysporum. This interaction often leads to the breakdown of fungal resistance in varieties that would otherwise remain healthy in the field.

196. (C) Infection predisposes the plant and breaks down resistance
Meloidogyne infection typically predisposes the host plant to fungal pathogens, often causing a breakdown of resistance in varieties that are normally resistant to Fusarium wilt. The physiological changes induced by the nematodes, combined with the physical wounds they create, make the plant more vulnerable to fungal invasion. This synergy means that managing nematodes is often essential for the effective control of soil-borne fungal diseases.

197. (A) Pratylenchus + Verticillium dahliae
The synergistic interaction between the lesion nematode Pratylenchus penetrans and the fungus Verticillium dahliae is responsible for early dying syndrome in potato. The presence of the nematode increases the incidence and severity of the fungal infection, leading to premature senescence and significant yield loss. This complex is a major concern for potato growers, as it can cause damage even when individual pest populations are relatively low.

198. (A) Meloidogyne kikuyensis
Kikuyu grass disease is associated with the root-knot nematode Meloidogyne kikuyensis. This nematode infects the roots of the grass, leading to significant reductions in growth and vigor. While less commonly discussed than other species, it is an important pest in specific pasture systems where Kikuyu grass is used as a primary forage crop. Managing its impact is necessary for maintaining the productivity of these grazing lands.

199. (A) Movement via water films generated by capillary action
Seed gall nematodes in the genus Anguina utilize thin water films generated by capillary action to climb the surfaces of moist plants. This ability allows the second-stage juveniles to migrate from the soil to the developing inflorescence at the top of the plant. By moving within these films during periods of high humidity or rain, the nematodes can reach their target tissues to initiate infection.

200. (A) Both A and R are true and R is the correct explanation of A.
Endoparasitic nematodes generally cause more severe damage to root systems because they invade and destroy internal tissues directly. By moving through or establishing permanent sites within the root cortex and vascular cylinder, they disrupt the plant's ability to transport water and nutrients. This internal destruction is often more debilitating to the plant than the localized damage caused by most ectoparasitic species.

201. (A) Labial papillae
Labial papillae are the anterior-most sensory structures surrounding the stoma of a nematode. These small, nipple-like projections are equipped with nerve endings that allow the nematode to sense its environment through physical contact. The arrangement and number of these papillae are important morphological characteristics used in the classification and identification of various nematode species, reflecting their importance in the organism's sensory biology.

202. (A) Stylet (or Stomatostylet/Odontostylet)
The stylet is the specialized, sclerotized, hollow spear found in plant-parasitic nematodes, used for feeding and host penetration. Depending on its evolutionary origin and structure, it is categorized as a stomatostylet or an odontostylet. This organ is essential for the nematode's survival, as it allows the parasite to pierce tough plant cell walls, inject digestive secretions, and ingest the liquefied cellular contents.

203. (A) Knobs
The base of the stomatostylet in the order Tylenchida typically possesses three thickened

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structures known as basal knobs. These knobs serve as the points of attachment for the protractor muscles that extend and retract the stylet during the feeding process. The size, shape, and arrangement of these knobs are critical diagnostic features used by taxonomists to differentiate between various nematode genera and species.

204. (A) Flanges or a simple expansion
In the order Dorylaimida, the stylet lacks the basal knobs found in Tylenchida and instead often features flanges or a simple basal expansion. These structures provide the necessary surface area for muscle attachment and support. This structural difference is a fundamental characteristic used to distinguish between these two major groups of plant-parasitic nematodes, reflecting their distinct evolutionary lineages and feeding mechanisms in the soil.

205. (A) Body length divided by maximum body width
In the standardized De Man's formula, the letter a represents the ratio of the total body length divided by the maximum body width of the nematode. This measurement provides a quantitative description of the nematode's slenderness or robustness. It is a consistent morphological parameter used in taxonomic descriptions, allowing researchers to compare different populations and species based on their overall body proportions.

206. (A) Vulva distance from the anterior end as a percentage
In De Man's formula, the parameter V represents the position of the vulva as a percentage of the total body length measured from the anterior end. This value is a critical diagnostic feature for female nematodes, as the location of the vulva is relatively stable within a species. Taxonomists use this percentage to help distinguish between similar genera and to characterize new species descriptions accurately.

207. (A) Pratylenchus
The genus Pratylenchus is characterized by having females with a single ovary, a condition known as monodelphic, and the vulva located towards the posterior end of the body. They are also prodelphic, meaning the ovary is directed anteriorly. These morphological features, combined with their migratory endoparasitic behavior, are essential for identifying this economically important group of lesion nematodes in various soil and root samples.

208. (A) Two ovaries
The term didelphic refers to a nematode that possesses two functional ovaries. This is a common characteristic in many plant-parasitic and free-living nematode species. The arrangement of these ovaries, whether they are directed in the same or opposite directions, provides further taxonomic information. Didelphic nematodes typically have a higher reproductive capacity, as both ovaries contribute to the production of eggs throughout the female's life.

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209. (A) Oppositely, one anteriorly and one posteriorly
If a nematode ovary is amphidelphic, it means the two ovaries are directed in opposite directions from the vulva, with one pointing anteriorly and the other posteriorly. This symmetrical arrangement is a key morphological feature used in the classification of various nematode groups. The presence of amphidelphic ovaries is often associated with specific genera and is easily observed under a compound microscope during diagnostic examinations.

210. (A) Xiphinema
The genus Xiphinema, commonly known as dagger nematodes, typically possesses an amphidelphic reproductive system, characterized by two ovaries directed in opposite directions. This feature is a consistent diagnostic character for the genus. Understanding the reproductive anatomy of Xiphinema is important for its identification and for studying its biology, as these nematodes are significant pests and vectors of several important plant viruses.

211. (A) Tylenchorhynchus (no overlap) and Helicotylenchus
The presence of a prominent, overlapping esophageal gland is a key diagnostic feature used to separate the genus Helicotylenchus from Tylenchorhynchus. In Helicotylenchus, the esophageal glands overlap the intestine dorsally or ventrally, whereas in Tylenchorhynchus, the glands are contained within a distinct basal bulb that does not overlap. This anatomical difference is easily observed and is essential for accurate genus-level identification.

212. (A) Punctodera cysts have vulval and anal fenestrae
The genus Punctodera is distinguished from Globodera by the presence of both vulval and anal fenestrae on the mature cysts. In Globodera, only the vulval area is fenestrated. This morphological difference is a critical diagnostic feature used to separate these two genera of cyst-forming nematodes. Punctodera species are important pests of various grasses and cereals, and accurate identification is necessary for effective management.

213. (A) Thin areas at the cyst end that rupture for escape
Fenestration in cyst nematodes refers to the presence of thin, transparent areas on the wall of the mature cyst, typically in the vulval or anal regions. These areas eventually rupture or break down, providing openings through which the second-stage juveniles can escape into the soil. The number, shape, and arrangement of these fenestrae are important taxonomic characters used to identify various species.

214. (A) Meloidogyne incognita
The bull's-eye perineal pattern is a characteristic morphological feature used to identify Meloidogyne incognita. This pattern is defined by a high, squarish dorsal arch with wavy striae that resemble a target or bull's-eye. While identification of root-knot nematodes can be challenging, the specific arrangement of these cuticular ridges remains one of the most reliable methods for distinguishing M. incognita from other closely related species.

215. (A) Lateral lines separating dorsal and ventral striae
The perineal pattern of Meloidogyne javanica is uniquely identified by the presence of distinct lateral lines that clearly separate the dorsal and ventral striae. These lines often appear as incisures that run across the pattern, creating a characteristic interrupted appearance. This feature is a consistent diagnostic marker for the species, allowing for its reliable identification during microscopic examination of mature female specimens.

216. (A) "Dirty roots" from soil adhering to the matrix
A classic symptom of the citrus nematode, Tylenchulus semipenetrans, is the appearance of dirty roots. This occurs because the soil particles adhere to the gelatinous matrix secreted by the protruding posterior bodies of the mature females. This gritty or encrusted appearance is a useful diagnostic indicator in the field, helping growers and researchers identify infestations of this specific semi-endoparasitic nematode.

217. (A) Preventing introduction and spread to new areas
Nematode quarantine laws are primarily aimed at preventing the introduction and subsequent spread of regulated pests into new, non-infested areas. These regulations involve monitoring the movement of soil, plants, and agricultural equipment across regional or international borders. By enforcing strict phytosanitary measures, authorities can protect local agriculture from the devastating impacts of exotic and economically significant nematode species.

218. (B) 1948
The Golden Nematode Act was established in the United States in 1948 to address the threat posed by the discovery of Globodera rostochiensis. This legislation provided the authority for intensive surveys, quarantine measures, and research to contain and manage this highly destructive potato pest. The act was a significant milestone in the history of regulatory nematology, highlighting the importance of government action in protecting agriculture.

219. (A) ISPM (International Standards for Phytosanitary Measures)
The International Standards for Phytosanitary Measures, developed under the International Plant Protection Convention, dictate the procedures for phytosanitary certification regarding nematodes and other pests. These global standards provide a harmonized framework for countries to implement effective quarantine and inspection protocols. By following ISPM guidelines, international trade in agricultural commodities can be conducted safely while minimizing the risk of spreading invasive nematode species.

220. (A) P-2, Q-1, R-4, S-3
Nematode management involves diverse approaches. Cultural methods include crop rotation to starve pests. Physical methods like soil solarization use heat to kill nematodes. Biological control utilizes natural enemies like

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the bacterium Pasteuria penetrans to parasitize the parasites. Finally, chemical management involves the application of nematicides such as oxamyl. Integrating these methods provides a sustainable and effective strategy for protecting crops.

221. (A) Methyl bromide
Methyl bromide was historically the most widely used fumigant nematicide globally due to its broad-spectrum efficacy against nematodes, weeds, and pathogens. However, it was phased out under international agreements because it is a potent ozone-depleting substance. Its removal from the agricultural market has driven the development and adoption of alternative nematode management strategies, including new chemicals, biological controls, and cultural practices.

222. (A) Montreal Protocol
The Montreal Protocol is the international agreement responsible for the global phase-out of methyl bromide and other ozone-depleting substances. This landmark treaty has significantly impacted agricultural pest management by requiring the adoption of safer alternatives for soil fumigation. The protocol's success in reducing the use of methyl bromide has contributed to the recovery of the ozone layer while promoting more sustainable agricultural practices.

223. (A) Acetylcholinesterase
Aldicarb, oxamyl, and carbofuran are nematicides that act by inhibiting the enzyme acetylcholinesterase in the nematode's nervous system. This enzyme is responsible for breaking down the neurotransmitter acetylcholine. By blocking its action, these chemicals cause a continuous accumulation of acetylcholine, leading to overstimulation of the nerves, paralysis, and eventually the death of the nematode. This mode of action is typical of carbamate pesticides.

224. (A) Glutamate-gated chloride channels
Abamectin is a natural fermentation product that targets glutamate-gated chloride channels in the nematode nervous system. By binding to these channels, it increases the permeability of the nerve cell membrane to chloride ions, leading to hyperpolarization and the suppression of nerve impulses. This action results in rapid paralysis and the cessation of feeding and movement, making abamectin a highly potent and specific nematicide.

225. (B) Fluoroalkenyl thioethers
Fluensulfone is a newer class of non-fumigant nematicide that belongs to the fluoroalkenyl thioether group. It represents a significant advancement in chemical nematode control, offering a novel mode of action that differs from traditional organophosphates and carbamates. Fluensulfone is effective against a wide range of plant-parasitic nematodes while having a more favorable environmental and safety profile compared to older chemical classes.

226. (A) Applied to foliage and translocated to protect roots
Systemic nematicides like oxamyl are highly advantageous because they can be applied to the foliage and then translocated within the plant to the roots. This systemic movement allows the chemical to protect the entire plant, including tissues that are difficult to reach with soil-applied treatments. This application method is particularly useful in certain cropping systems where soil application is impractical or less effective.

227. (A) Promoting natural enemies and toxic byproducts
Soil amendments using organic matter help control nematodes primarily by promoting the activity of natural enemies and creating toxic byproducts during decomposition. The addition of compost or manure increases the populations of nematophagous fungi and predatory microbes. Furthermore, the breakdown of organic material releases compounds like ammonia and organic acids, which can be directly lethal to plant-parasitic nematode species.

228. (A) Isothiocyanates
Isothiocyanates are the primary biofumigant compounds released during the decomposition of brassicaceous crops like mustard. These volatile chemicals are produced when glucosinolates in the plant tissue are broken down by the enzyme myrosinase. Isothiocyanates have broad-spectrum toxicity against various soil-borne pests, including nematodes, and their use in biofumigation is a sustainable practice for reducing nematode populations in agricultural soils.

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229. (A) Seinhorst's damage function model
Seinhorst's damage function model is frequently used to describe the relationship between the initial nematode population density and the resulting crop yield loss. This mathematical model provides a sigmoid curve that quantifies how yield decreases as the nematode population increases. It is an essential tool for establishing economic thresholds and for predicting the impact of nematode damage on agricultural productivity.

230. (A) Tolerance limit (threshold below which no damage occurs)
In Seinhorst's equation, the parameter T represents the tolerance limit, which is the nematode population density below which no measurable crop damage occurs. This threshold is critical for determining the level of infestation that a specific crop can withstand before management intervention becomes necessary. Understanding the tolerance limit for different host-parasite combinations is fundamental to the practical application of integrated nematode management.

231. (A) $\frac{Pf}{Pi}$ (Final population divided by Initial population)
The reproductive factor of a nematode population is calculated by dividing the final population density by the initial population density. This ratio provides a measure of the nematode's ability to multiply on a specific host plant under given environmental conditions. The Rf value is a fundamental parameter used in host suitability studies and in the evaluation of crop resistance to various nematode species.

232. (A) A susceptible host allowing nematode multiplication
An Rf value greater than one indicates that the plant is a susceptible host that allows the nematode population to multiply. In this case, the final population is larger than the initial population, showing that the plant provides the necessary nutrients and environment for the parasite to complete its life cycle and reproduce. Susceptible hosts are the primary targets for nematode management strategies.

233. (A) Intolerant resistant
In resistance screening, a plant that suffers significant yield reduction but restricts nematode reproduction, resulting in an Rf value less than one, is termed intolerant resistant. This means that while the plant is not a good host for the nematode, it is highly sensitive to the initial damage caused by the parasite's penetration and feeding activity. Such plants are generally not ideal for commercial production.

234. (A) A tolerant plant
A tolerant plant is one that supports high nematode reproduction but shows little or no yield reduction. In this case, the Rf value is greater than one, indicating host suitability, but the plant's overall growth and productivity remain largely unaffected by the infection. Tolerance is an important trait in crop breeding, as it allows for stable yields even in nematode-infested fields.

235. (B) Bursaphelenchus cocophilus
Bursaphelenchus cocophilus is the nematode associated with red ring disease in coconut and oil palms. This devastating disease is characterized by the appearance of a distinct red or brownish ring in the stem tissue of the palm. The nematode invades the vascular tissues, leading to the rapid decline and death of the tree. It is a major economic threat to palm plantations.

236. (A) By the South American palm weevil
The red ring nematode is primarily transmitted from palm to palm by the South American palm weevil, Rhynchophorus palmarum. The weevil acts as a biological vector, carrying the nematodes from infested trees to healthy ones during its feeding and egg-laying activities. This close association between the insect and the nematode is a critical factor in the epidemiology and spread of red ring disease.

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237. (A) Monochamus species (Pine sawyer beetles)
The pine wood nematode, Bursaphelenchus xylophilus, is vectored by Monochamus species, also known as pine sawyer beetles. These beetles carry the nematodes in their tracheae and transmit them to healthy pine trees as they feed on the bark. Once inside the tree, the nematodes multiply rapidly in the resin ducts, leading to the rapid wilting and death of the host tree.

238. (A) 21-30 days
Under optimal environmental conditions, typically between 25 and 30 degrees Celsius, the life cycle of Meloidogyne incognita takes approximately 21 to 30 days to complete.

This rapid development allows for multiple generations within a single cropping season, leading to exponential population growth and severe damage to host plants. Understanding the duration of the life cycle is essential for timing management interventions effectively.

239. (A) Gubernaculum
The gubernaculum is the sclerotized structure responsible for guiding the spicules during copulation in male nematodes. It is a modification of the dorsal wall of the spicular pouch and helps ensure that the spicules are correctly directed into the female's vulva. The presence, size, and shape of the gubernaculum are important morphological features used in the taxonomic description and identification of many nematode species.

240. (A) Apoplysis → Epicuticle formation → Ecdysis
The typical nematode molting process follows a specific sequence of events: apolysis, epicuticle formation, and ecdysis. Apolysis involves the separation of the old cuticle from the underlying hypodermis. This is followed by the synthesis of the new epicuticle. Finally, ecdysis occurs, which is the actual shedding of the previous cuticle. This synchronized process is essential for the growth and development of all juvenile stages.

241. (A) Separation of old cuticle from the hypodermis
Apolysis is the first stage of the molting process in nematodes, characterized by the separation of the old cuticle from the underlying hypodermis. This process creates a space where the new cuticle will be synthesized. Apolysis is a complex physiological event controlled by hormonal signals, marking the transition from one developmental stage to the next as the nematode grows and matures.

242. (A) A large multinucleate cell formed by cell wall fusion
A syncytium is a large multinucleate cell formed by the dissolution of cell walls and the subsequent fusion of the protoplasts of adjacent host cells. This specialized feeding structure is induced by cyst nematodes and acts as a highly efficient nutrient sink. By creating a single continuous mass of cytoplasm with multiple nuclei, the nematode ensures a concentrated and abundant supply of nutrients.

243. (A) Stylet
The pharyngeal or esophageal glands of plant-parasitic nematodes secrete specialized effectors into the host plant primarily through the hollow stylet. These molecules are injected into the host cells during the initial stages of infection to suppress plant defenses and manipulate host metabolism. The stylet therefore serves as both a physical tool for penetration and a chemical delivery system for the parasite.

244. (A) Alter host metabolism, suppress defenses, and help parasitism
Nematode effectors are molecules secreted by the parasite into the host plant to alter host metabolism, suppress plant immune defenses, and facilitate successful parasitism. These effectors can include proteins, small molecules, and RNAs that target specific plant pathways. By manipulating the host environment, the nematode ensures it can establish a feeding site and complete its life cycle without being rejected by the plant.

245. (A) Bacteria
One of the pioneering discoveries in nematology was that cellulase genes in plant-parasitic nematodes likely originated from bacteria through horizontal gene transfer. This evolutionary event provided nematodes with the ability to digest cellulose, a major component of plant cell walls. This capacity was a critical step in the evolution of plant parasitism, allowing these organisms to invade and feed on diverse plant species.

246. (A) Digest host cell walls during penetration and migration
The role of nematode-secreted cellulases and pectate lyases is to digest host cell walls during the processes of penetration and migration. These enzymes break down the structural components of the plant tissue, such as cellulose and pectin, making it easier for the nematode to move between cells and reach the vascular tissues. This enzymatic activity is a key factor in the pathogenesis.

247. (A) Chitin
The chorion, which is the structural layer of the nematode eggshell, is comprised primarily of chitin. This tough, fibrous polysaccharide provides the egg with mechanical strength and protection from physical damage. The presence of chitin is a characteristic feature of nematode

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eggs and is essential for their survival in the soil environment, where they are exposed to various abiotic and biotic stresses.

248. (A) Lipid layer
The innermost layer of the nematode eggshell is the lipid layer, which is crucial for preventing desiccation and regulating permeability. This waxy layer acts as a barrier to water loss and protects the developing embryo from toxic substances in the soil. The integrity of the lipid layer is essential for the long-term viability of the eggs, especially in species that must survive dry seasons.

249. (A) Host cells modified by the nematode to supply nutrients
A nurse cell system consists of host plant cells that have been modified by the nematode to become specialized nutrient sources. Once the nematode establishes a feeding site, it induces the surrounding cells to enlarge, increase their metabolic activity, and accumulate high concentrations of proteins and sugars. These nurse cells then supply all the sustenance required for the sedentary nematode to grow and reproduce.

250. (B) Trichodorus → Pratylenchus → Meloidogyne
The classification of plant-parasitic nematodes based on feeding behavior is essential for understanding their ecological impact. For instance, Trichodorus species feed from the outside as migratory ectoparasites. Pratylenchus species move through root tissues as migratory endoparasites, causing extensive necrotic lesions. Finally, Meloidogyne species establish permanent sites as sedentary endoparasites, inducing the formation of characteristic galls within the host's root system.

251. (A) Host nutritional status and crowding factors
In Meloidogyne species, sex determination is heavily influenced by environmental factors such as host nutritional status and crowding within the root. Unlike many other animals, the sexual fate of the nematode can be altered by the conditions it encounters during its early juvenile stages. These cues allow the population to adapt its reproductive strategy to the available resources, ensuring survival under varying levels of stress.

252. (A) A high proportion of males
Under conditions of severe crowding or poor host nutrition, Meloidogyne populations will typically develop into a high proportion of males. This shift occurs because male development is less nutritionally demanding than female development. The production of more males under stress is a common phenomenon in several sedentary nematode species, serving as a biological indicator of unfavorable environmental conditions or high population pressure.

253. (A) Environmental stress, with reproduction staying parthenogenetic
The occurrence of males in Meloidogyne incognita populations primarily indicates environmental stress, although the reproduction typically remains parthenogenetic. While the species is capable of producing males, they are not usually required for fertilization in many common populations. The presence of males serves as a morphological marker that the nematodes are experiencing sub-optimal conditions, such as resource competition or host resistance.

254. (A) Multiply on specific resistant crop cultivars
Pathotypes in nematodes are populations of a given species that are distinguished by their ability to multiply on specific resistant crop cultivars. Identifying these pathotypes is critical for effective pest management, as a variety that is resistant to one population might be completely susceptible to another. This variability necessitates the continuous screening and development of diverse resistance genes in plant breeding programs.

NODIA

255. (A) Meloidogyne incognita
The concept of physiological races is heavily documented in Meloidogyne incognita, which is one of the most important nematode species affecting global agriculture. These races are defined by their ability to reproduce on a set of differential host plants. Understanding the distribution of these races is essential for implementing successful crop rotation and resistance strategies, as different races have distinct host range preferences.

256. (A) Races of Meloidogyne incognita and M. arenaria
The North Carolina Differential Host Test is a standardized procedure used to identify the different physiological races of Meloidogyne

incognita and Meloidogyne arenaria. By inoculating a set of specific plant varieties and observing the reproductive response, researchers can determine the race of a given nematode population. This information is vital for recommending appropriate resistant cultivars to farmers in infested regions.

257. (A) Tobacco, Cotton, Pepper, Watermelon, Peanut, Tomato
The standard North Carolina Differential Host Test includes a set of indicator crops such as tobacco, cotton, pepper, watermelon, peanut, and tomato. Each of these plants exhibits a specific reaction to different races of root-knot nematodes. By analyzing the galling and reproduction on these hosts, scientists can accurately classify the nematode population into its respective physiological race for management purposes.

258. (A) Cotton (cv. Deltapine)
Meloidogyne incognita Race 1 is distinguished from Race 3 by its inability to reproduce on certain cultivars of cotton, such as Deltapine. This specific host response is a key component of the differential test used to classify these races. Identifying whether a population is Race 1 or Race 3 is essential for growers in cotton-producing regions to select effective management strategies.

259. (A) Simultaneous infection of a host by two or more species
A concomitant infection refers to the simultaneous infection of a single host plant by two or more different nematode species. In agricultural fields, it is common to find multiple genera, such as Meloidogyne and Pratylenchus, inhabiting the same root system. These interactions can be complex, often leading to competition for resources or synergistic damage that exceeds the impact of either species alone.

260. (A) Competition for feeding sites and space
During concomitant infections, antagonistic interactions between different nematode species often occur due to competition for limited feeding sites and physical space within the root. One species may dominate by establishing its feeding site more quickly or by altering the host's physiology in a way that makes it less suitable for the other species. This competition can significantly influence the population dynamics of the nematode community.

261. (A) Endoreduplication
In root-knot nematode infected tissues, the expression of genes involved in the plant cell cycle is heavily manipulated, leading to a process called endoreduplication. This involves repeated rounds of DNA synthesis without intervening cell division. This mechanism is essential for the formation of massive giant cells, which require high levels of DNA and metabolic activity to provide the nutrients needed by the sedentary parasite.

262. (A) Cells with multiplied DNA content and large, lobed nuclei
Endoreduplication in giant cells results in the formation of cells with greatly multiplied DNA content and exceptionally large, lobed nuclei. This increased genetic capacity supports the high metabolic activity required for nutrient production. These specialized cells are the primary source of food for the sedentary female nematode, and their unique nuclear morphology is a hallmark of the root-knot nematode feeding site.

263. (A) Transfer cells
The cell walls of giant cells possess specialized ingrowths that greatly increase the surface area for solute transport, making them similar in structure and function to transfer cells found in plants. These wall ingrowths facilitate the rapid movement of nutrients from the surrounding vascular tissues into the giant cell. This adaptation ensures that the nematode has a constant and concentrated supply of sustenance for its growth.

264. (A) Severe necrosis and "stubby root" appearance
Roots heavily infected by the sting nematode, Belonolaimus longicaudatus, exhibit severe necrosis and a characteristic stubby root appearance. This large ectoparasite feeds at the root tips, causing immediate cessation of growth and death of the meristematic tissue. The resulting root system is poorly developed and unable to support the plant's water and nutrient needs, leading to significant stunting and wilting symptoms.

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265. (A) Sandy soils
Belonolaimus longicaudatus is primarily problematic in sandy soils, where the large pore spaces facilitate its movement. This nematode is one of the largest plant-parasitic species and requires well-aerated, coarse-textured environments to thrive. Its impact is particularly severe in coastal regions and other areas with sandy agricultural land, where it can cause devastating losses to a wide variety of crops and turfgrasses.

266. (A) Fosthiazate
Fosthiazate is a chemical that is typically considered a contact nematicide. It belongs to the organophosphate class and acts primarily by direct contact with the nematodes in the soil. This type of nematicide is used to provide rapid suppression of nematode populations in the root zone. Effective application requires thorough incorporation into the soil to ensure maximum contact with the target pests.

267. (A) Soil fumigant
1,3-Dichloropropene functions primarily as a soil fumigant, which is a chemical that turns into a gas upon application to the soil. The gas diffuses through the soil pores, killing nematodes and other soil-borne pests upon contact. Fumigants are highly effective because they can reach greater depths and more complex environments than liquid nematicides, making them a powerful tool for pre-plant soil sterilization.

268. (A) Volatilization and diffusion in soil are required for efficacy
Soil conditions such as moisture and temperature are critical when applying fumigants because their efficacy depends on the processes of volatilization and diffusion through the soil matrix. The chemical must turn into a gas and spread evenly through the pore spaces to reach all the target nematodes. If the soil is too wet or too cold, these processes are hindered, leading to poor pest control.

269. (A) Rapid breakdown of a nematicide by adapted soil microbes
Enhanced biodegradation refers to the rapid breakdown of a nematicide by soil microbes that have adapted to use the chemical as a nutrient or energy source. This phenomenon often occurs after repeated applications of the same pesticide to the same field. As the microbial population grows, the nematicide is degraded so quickly that it fails to provide effective control, necessitating changes in management.

NODIA

270. (A) Fenamiphos
Enhanced biodegradation was a major factor in the loss of efficacy of the nematicide fenamiphos in several agricultural regions. After years of successful use, the soil microflora in many fields adapted to degrade the chemical rapidly, significantly shortening its persistence and reducing its ability to control nematode populations. This problem highlights the need for rotating different classes of nematicides to prevent microbial adaptation.

271. (A) Soil where disease is suppressed by beneficial microflora
In nematology, a suppressive soil is one where nematode-induced disease is kept at low levels by the activity of beneficial microflora, even in the presence of a susceptible host. This suppression is often biological, involving nematophagous fungi, parasitic bacteria, or other natural enemies. Understanding the mechanisms behind suppressive soils is a key area of research for developing sustainable and natural pest management strategies.

272. (A) Nematophthora gynophila and Verticillium chlamydosporium
The decline of cereal cyst nematode populations in monoculture wheat fields in Europe was largely attributed to parasitism by specialized fungi, including Nematophthora gynophila and Verticillium chlamydosporium. These natural enemies attack the females and eggs of the nematode, providing a biological check on the population. This discovery provided one of the first examples of natural biological control in a large-scale agricultural system.

273. (A) Developing females before they form protective cysts
Nematophthora gynophila targets the developing females of cyst nematodes before they have a chance to form their hard, protective cysts. The fungus infects the female body while it is still soft and exposed on the root surface, rapidly consuming the internal contents. This effectively prevents the formation of eggs and cysts, leading to a significant reduction in the soil nematode population over time.

274. (A) The plant's ability to yield well despite nematode reproduction
Tolerance in plant nematology refers to a plant's inherent ability to produce a good yield even when it is infected by a high population of nematodes. Unlike resistance, which restricts the reproduction of the parasite, tolerance focused on the plant's capacity to withstand the damage. Tolerant varieties are valuable in agricultural settings where nematode eradication is not feasible or economically practical.

275. (A) Transfer of undesirable traits linked to the resistance gene
Breeding for nematode resistance is often complicated by linkage drag, which is the transfer of undesirable traits that are genetically linked to the resistance gene. These traits can include reduced yield, poor quality, or susceptibility to other diseases. Breeders must work to break these linkages through repeated backcrossing and selection to produce high-performing cultivars that also possess the necessary nematode resistance.

276. (A) HIGS via RNA interference
Host-induced gene silencing via RNA interference is an innovative molecular technique used to manage nematodes by silencing essential genes. Transgenic plants are engineered to produce double-stranded RNA that is homologous to a target nematode gene. When the nematode feeds on the plant, it ingests the dsRNA, which triggers the silencing of the target gene, leading to reduced fitness or death.

277. (A) dsRNA homologous to a target nematode gene
In an RNAi approach against nematodes, the transgenic host plant is engineered to express double-stranded RNA that is perfectly homologous to an essential target gene within the nematode. This dsRNA is designed to trigger the nematode's own RNA interference machinery upon ingestion. By silencing genes critical for development, feeding, or reproduction, this biotechnology provides a highly specific and effective method of control.

278. (A) Meloidogyne hapla
Meloidogyne hapla, known as the northern root-knot nematode, is generally adapted to cooler climates and is a major pest of vegetables and other crops in temperate regions. Unlike most other root-knot nematodes that thrive in tropical areas, M. hapla can survive cold winters and complete its life cycle at lower temperatures. Its distribution and impact are therefore characteristic of high-latitude agricultural systems.

279. (A) Punctations in the tail terminal area above the anus
Meloidogyne hapla can be morphologically distinguished by its unique perineal pattern, which features fine punctations or dots in the tail terminal area above the anus. This characteristic detail is a reliable diagnostic marker for the species. Additionally, the pattern is often described as having a low, rounded dorsal arch with smooth striae, which helps differentiate it from other common root-knot species.

280. (A) Destruction of the primary root apical meristem
The distinct forked or heavily branched root symptoms commonly seen on carrots infected by Meloidogyne hapla are caused by the destruction of the primary root apical meristem. When the nematode infects the young root tip, it halts the elongation of the taproot and stimulates the development of multiple lateral roots. This results in deformed, unmarketable carrots, significantly reducing the commercial value.

281. (A) Maize
The cyst nematode Heterodera zeae is an important pest of maize in India, particularly in the northern and western regions of the country. It was first described from India and is known as the corn cyst nematode. The infection leads to stunting, yellowing, and reduced ear formation. Managing this nematode is important for ensuring the productivity of maize, especially in intensive cropping systems.

282. (B) They have a wide host range spanning many plant families
The term polyphagous as applied to many root-knot nematodes means that they possess a very wide host range spanning hundreds of different plant species across many botanical families. This broad adaptability makes them some of the most difficult agricultural pests to manage, as they can thrive on almost any crop or weed present in a field, rendering many rotation schemes ineffective.

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283. (A) Trap cropping
Heterodera schachtii, the sugarbeet cyst nematode, was historically important for being one of the first plant-parasitic nematodes targeted for management using the cultural practice of trap cropping. By planting a susceptible host and destroying it before the nematodes could complete their life cycle, farmers in the 19th century were able to reduce the soil population and protect subsequent sugarbeet crops.

284. (A) Julius Kuhn
Julius Kuhn was an early pioneer in nematology who developed one of the first methods of trap cropping specifically to manage the sugarbeet cyst nematode. His work in the late 19th century demonstrated that planting a susceptible crop like rape and then removing it before the nematodes matured could significantly lower the soil infestation levels. This innovative approach was an early milestone.

285. (A) It starves obligate nematodes, reducing the population
In integrated pest management, the role of a non-host crop in a rotation scheme is to starve obligate plant-parasitic nematodes, thereby naturally reducing the soil population. Since these nematodes require a suitable host to feed and reproduce, planting a crop that they cannot parasitize causes the juveniles to hatch and die from lack of nutrition, breaking the life cycle.

286. (A) Banana biotype
Radopholus similis isolates that only attack banana and are unable to parasitize citrus are referred to as the banana biotype. This physiological differentiation is significant for crop management and quarantine purposes. In regions where only the banana biotype is present, citrus orchards remain safe from infection. Identifying the specific biotype is essential for predicting the potential impact on different crops in the area.

287. (A) Banana is perennial, making rotation difficult
A major feature that prevents the effective use of crop rotation against Radopholus similis in many regions is that banana is a perennial crop. Because the host is present in the field for many years, the nematode has a continuous supply of roots and can maintain high population densities indefinitely. This perennial nature makes it difficult to implement the fallow or non-host periods.

288. (A) Mucro
Hirschmanniella species possess a characteristic small, pointed projection at the tip of their tail known as a mucro. This morphological feature is a useful diagnostic character for the genus. The shape and presence of the mucro, along with other tail characteristics, help taxonomists distinguish these rice root nematodes from related genera. Its presence is easily observed during microscopic examinations of vermiform stages.

289. (A) Hoplolaimus
The condition known as a mentum, where the lip region is set off by a distinct constriction and has a thickened appearance, is a morphological feature often associated with the genus Hoplolaimus. This robust head structure provides the necessary support for the muscles that operate the nematode's powerful stylet. It is a defining characteristic used in the taxonomic identification of lance nematodes in soil samples.

NODIA

290. (A) Prominent, thick cuticle giving a ringed appearance
Nematodes belonging to the family Criconematidae, known as ring nematodes, are easily recognized by their prominent, thick cuticle that gives the body a distinctly ringed appearance. These annules are often very large and may have scales or spines. This unique morphology is a definitive diagnostic feature of the group, reflecting their specialized adaptation to a slow-moving, ectoparasitic lifestyle in the soil.

291. (A) Ring nematodes
Macroposthonia and Criconemella are two genera commonly known as ring nematodes. These names refer to the characteristic heavily annulated cuticle that encircles their bodies. They are migratory ectoparasites that feed on a wide variety of woody and herbaceous plants. Their sluggish movement and unique body structure make them easy to identify during microscopic examinations of soil samples from orchards and turfgrass.

292. (A) Ectoparasites
Ring nematodes move very sluggishly due to their thick, heavily annulated cuticle and

typically feed as ectoparasites. They remain in the soil throughout their lives, using their relatively long stylets to feed on the epidermal cells of the host roots. Their slow movement is a direct consequence of their unique body design, which differs significantly from the more active vermiform shapes of other nematodes.

293. (A) Sodium chloride or sucrose
The centrifugation-flotation method commonly utilizes a high-density solution of sucrose or sodium chloride to float nematodes out of a soil suspension. Because nematodes have a lower specific gravity than the surrounding soil particles, they rise to the surface of the dense solution during centrifugation. This technique is highly efficient for concentrating nematodes from soil samples, providing a clean suspension for microscopy.

294. (A) Extracts active and inactive nematodes from soil
A primary advantage of the centrifugation-flotation extraction method over the Baermann funnel is that it extracts both active and inactive nematodes from the soil. Unlike methods that rely on nematode motility, this physical separation technique captures all vermiform stages regardless of their condition. This makes it more suitable for estimating the total population density, including dormant or stressed individuals that might be missed.

295. (A) High-resolution compound microscope with DIC
Detailed taxonomic identification of plant-parasitic nematodes fundamentally requires a high-resolution compound microscope, often equipped with differential interference contrast optics. This equipment is necessary to observe the minute internal and external features, such as the stylet base, esophageal glands, and reproductive structures, that are essential for distinguishing between different species and genera in the diverse and complex phylum Nematoda.

296. (A) Sinking velocities in upward water currents
The Oostenbrink elutriator is a piece of equipment used to separate nematodes from soil based on the differences in their sinking velocities in upward water currents. As water flows upward through a column, lighter particles like nematodes are carried to the top, while heavier soil particles sink to the bottom. This method allows for the processing of large soil samples.

297. (A) Bionematicides based on Azadirachtin (Neem)
Bionematicides based on azadirachtin, derived from the neem tree, are considered environmentally friendly, plant-derived products that are commercially available for nematode control. These products provide a natural alternative to synthetic nematicides, working by disrupting the nematode's growth, feeding, and reproduction. Their use is increasing in sustainable agricultural systems as part of an integrated approach to managing plant-parasitic nematode populations safely.

298. (B) 50-55°C
To ensure the safe movement of agricultural commodities, treating plant materials with hot water requires precise temperature control. A typical effective range for hot water treatment is 50 to 55 degrees Celsius for a specific duration, usually 15 to 30 minutes. This temperature is sufficient to kill internal nematodes while remaining below the threshold that would cause significant damage or death to the plant tissue.

NODIA

299. (A) Secondary symptoms from impaired root function
Above-ground symptoms such as chlorosis and wilting in nematode-infected plants are considered secondary symptoms resulting from impaired root function. Because the nematodes damage the root system's ability to absorb and transport water and nutrients, the plant exhibits signs of deficiency and stress. These general symptoms are the indirect result of the direct parasitic activity occurring below the soil surface level.

300. (A) Integrated Nematode Management (INM)
Integrated Nematode Management is a sustainable strategy that combines various control tactics to keep nematode populations below the economic threshold level. This approach prioritizes the use of resistant crop varieties, diverse crop rotations, and biological control agents while minimizing reliance on harsh chemical nematicides. By integrating these methods, farmers can achieve effective long-term pest suppression while protecting the environment and agriculture.

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CHAPTER 02
Nematode Taxonomy and Morphology

2023

1. Which of the following best describes the fundamental body cavity plan of nematodes?
(A) A pseudocoelom lacking a continuous mesodermal lining
(B) A true coelom lined with mesoderm-derived peritoneum
(C) A solid body cavity filled entirely with parenchymal tissue
(D) A hemocoel integrated with an open circulatory system

2017

2. What is the primary functional role of the hydrostatic skeleton in nematodes?
(A) Excretion of nitrogenous waste across the thin cuticle
(B) Structural framework for the attachment of internal organs
(C) Locomotion using muscle contractions against fluid pressure
(D) Active transport of oxygen to internal reproductive systems

2022

3. In the context of nematode embryology, what characterizes their triploblastic development?
(A) The presence of ectoderm, mesoderm, and endoderm germ layers
(B) The formation of three distinct cuticular layers post-hatching
(C) The development of a three-part digestive tract (stoma, esophagus, intestine)
(D) The division of the body into three distinct functional tagmata

2015

4. Which of the following is an INCORRECT statement regarding nematode general morphology?
(A) They possess longitudinal muscles but lack circular muscles in their body wall
(B) Their epidermis may be cellular or syncytial depending on the taxon
(C) The body is typically bilaterally symmetrical with secondary radial symmetry in the head region
(D) They exhibit a highly developed continuous respiratory system

2012

5. The high internal turgor pressure of the nematode pseudocoelom directly necessitates which of the following physiological adaptations?
(A) A complex network of flame cells for osmoregulation
(B) A muscular pharynx to pump food against internal pressure
(C) Absence of an excretory system to maintain fluid volume
(D) A rigid, calcified exoskeleton to prevent body rupture

2023

6. Which morphological feature distinguishes nematodes from related pseudocoelomate groups like Rotifera?
(A) The presence of a complete digestive tract
(B) The existence of a distinct head and tail region
(C) Absence of functional cilia or flagella in somatic cells
(D) The utilization of a hydrostatic skeleton for movement

2022

7. According to the Ecdysozoa hypothesis, which fundamental characteristic unites Phylum Nematoda with Phylum Arthropoda?
(A) Possession of jointed appendages during the larval stages
(B) Formation of a true coelom within the adult organism
(C) Utilization of a hemocoel for internal nutrient transport
(D) Periodic moulting of a cuticle mediated by ecdysteroids

2007

8. In comparative phylogenetics, how do Tardigrada and Nematoda primarily differ?
(A) Tardigrades possess lobopodal legs, whereas nematodes are unsegmented and legless
(B) Tardigrades undergo ecdysis, whereas

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nematodes do not
(C) Tardigrades are strictly marine, whereas nematodes are exclusively terrestrial
(D) Tardigrades have a pseudocoelom, whereas nematodes possess a true coelom

2017

9. Phylum Nematomorpha is closely related to Nematoda. Which feature distinguishes adult nematomorphs from adult nematodes?
(A) Nematomorphs possess a well-developed, functioning feeding apparatus
(B) Adult nematomorphs have a degenerate gut and no excretory system
(C) Nematomorphs have highly developed circular muscles in their body wall
(D) Nematomorphs replicate via binary fission rather than sexual reproduction

2025

10. Identify the most appropriate statement detailing the evolutionary placement of nematodes.
(A) Lophotrochozoans characterized by their spiral cleavage
(B) Ecdysozoans defined by rDNA and moulting behaviors
(C) Deuterostomes defined by blastopore-to-mouth origin
(D) Basal Metazoans that lack fundamental bilateral symmetry

2024

11. Which major evolutionary transition is best reflected by the grouping of Nematoda within Ecdysozoa rather than with other "pseudocoelomates"?
(A) Independent loss of the coelom from a coelomate ancestor
(B) The transition from an unsegmented to a metameric body plan
(C) The acquisition of a chitinous exoskeleton in all representative phyla
(D) The evolutionary shift from parasitic to predominantly free-living lifestyles

2007

12. Which of the following is NOT a recognized synapomorphy or shared trait of the supergroup Ecdysozoa?
(A) A layered cuticle composed of organic materials
(B) The lack of locomotory cilia
(C) The universal presence of a closed circulatory system
(D) The moulting of the cuticle regulated by specific hormones

2006

13. Which combination of phyla is most appropriately classified alongside Nematoda in the clade Nematoida?
(A) Arthropoda and Tardigrada
(B) Kinorhyncha and Loricifera
(C) Rotifera and Acanthocephala
(D) Nematomorpha

2025

14. Who is widely regarded as the "Father of American Nematology" due to his foundational work on nematode taxonomy and extraction techniques?
(A) B. G. Chitwood
(B) H. C. Bastian
(C) Nathan Augustus Cobb
(D) T. Goodey

NODIA

2013

15. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): B.G. Chitwood's bipartite classification divided Nematoda into Secernentea and Adenophorea primarily based on the presence or absence of phasmids.
Reason (R): Phasmids are critical sensory structures located in the cephalic region of all parasitic nematodes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

16. Which scientist authored the classical comprehensive textbook "An Introduction to Nematology"?
(A) N. A. Cobb
(B) T. Goodey
(C) J. G. de Man
(D) B. G. Chitwood

2024

17. The monograph "Monograph on the Anguillulidae", published in 1865, laid early taxonomic foundations for free-living and plant-parasitic nematodes. Who was its author?
(A) H. C. Bastian
(B) J. G. de Man
(C) T. Goodey

(D) A. A. Paramonov

2001

18. Which researcher is primarily credited with standardizing the morphological formulas (e.g., a, b, c indices) used in nematode taxonomy?
(A) N. A. Cobb
(B) B. G. Chitwood
(C) J. G. de Man
(D) M. W. Allen

2015

19. T. Goodey made significant historical contributions primarily through which of the following works?
(A) Publishing "Plant Parasitic Nematodes and the Diseases they Cause"
(B) Developing the first molecular barcode for nematodes
(C) Discovering the first entomopathogenic nematode
(D) Creating the modern SSU rDNA phylogenetic tree

2017

20. Which of the following is an INCORRECT pairing of a nematologist and their major contribution?
(A) N. A. Cobb - Formulation of the stylet-bearing nematode classification framework
(B) J. G. de Man - Introduction of morphometric indices
(C) B. G. Chitwood - Proposal of the Secernentea and Adenophorea classes
(D) H. C. Bastian - Discovery of the first nematode genome sequence

2022

21. Which historical milestone marked the first clear scientific observation of plant-parasitic nematodes (wheat seed gall)?
(A) Berkeley's description of root-knot in 1855
(B) Needham's observation in 1743
(C) Kuhn's documentation of stem nematode in 1857
(D) Schacht's discovery of the sugarbeet cyst nematode in 1859

2003

22. Which alpha taxonomic principle specifically deals with the initial description and naming of a new nematode species?
(A) Assessing phylogenetic relationships among genera
(B) Formulating higher-level evolutionary clades
(C) Documenting features and establishing type specimens
(D) Utilizing genomic alignments to correct synonymies

2001

23. Gamma taxonomy in nematology focuses primarily on which of the following aspects?
(A) Regional fauna checklists and catalog compilation
(B) Arrangement of species into generic categories
(C) Morphometric measurement of standard type materials
(D) Intraspecific variation and speciation mechanisms

2021

24. What is the defining characteristic of the Morphological Species Concept as applied to nematology?
(A) Species are diagnosed based on consistent, observable structural differences
(B) Species are defined by reproductive isolation in natural habitats
(C) Species are defined solely by fixed percentage differences in the ITS region
(D) Species are recognized by their distinct ecological niches and host ranges

2014

25. Match the ICZN terminologies in List I with their correct definitions in List II regarding nematode taxonomy.
List I: (Terms)
P. Synonym
Q. Homonym
R. Topotype
S. Basionym
List II: (Definitions)
1. The original name on which a new combination is based
2. A specimen collected from the exact type locality of a species
3. A name that is identical to another name proposed for a different taxon
4. One of two or more names applied to the same taxon
(A) P-4, Q-3, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

2008

26. Under the ICZN rules, what does the Principle of Priority mandate?

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(A) The most recently described name replaces all previous names
(B) The oldest available, validly published name for a taxon is its accepted name
(C) Names given by native researchers have priority over foreign authors
(D) Molecular-based names always supersede morphology-based names

2013

27. When a nematode species is transferred to a different genus, how must the authorship be cited according to ICZN rules?
(A) The original author's name is placed in parentheses, optionally followed by the new author's name
(B) The original author's name is dropped entirely
(C) The new author's name is placed in parentheses followed by the original author
(D) Only the year of the new transfer is appended to the species name

2006

28. Which situation results in an objective synonym in nematode taxonomy?
(A) Two taxonomists describe the same species based on different type specimens
(B) A species is moved to a new genus based on molecular data
(C) Two different names are explicitly based on the same type specimen
(D) A previously described species is found to be extinct

2024

29. According to binomial nomenclature, which statement represents the correct formatting for a newly proposed nematode species?
(A) Meloidogyne Incognita sp. nov.
(B) meloidogyne incognita sp. nov.
(C) Meloidogyne incognita Sp. Nov.
(D) Meloidogyne incognita sp. nov.

2016

30. What is the primary cause of a subjective synonym in systematic nematology?
(A) A taxonomist proposing a replacement name for a junior homonym
(B) The accidental loss of the original holotype specimen
(C) Taxonomists differing in their opinion on whether two distinct type specimens represent the same species
(D) The publication of two identical names for different species in the same year

2001

31. Under the ICZN, what happens if a nematode name is published without a designated type specimen or description after 1999?
(A) It becomes a valid senior synonym
(B) It is considered a nomen nudum and is unavailable
(C) It is automatically assigned to a closely related genus
(D) It remains valid but cannot be used in formal keys

2006

32. What is the strictly defined role of a holotype in nematode taxonomic typification?
(A) A specimen collected from the same host plant as the original species
(B) A composite description derived from multiple representative specimens
(C) A replacement specimen designated when the original is confirmed destroyed
(D) The single physical specimen designated to represent the species

2019

33. In nematode taxonomy, what distinguishes a paratype from a syntype?
(A) Paratypes are extra specimens with a holotype; syntypes are used when no holotype is designated
(B) Paratypes are compared with different species; syntypes are the main series
(C) Paratypes are the opposite sex; syntypes are of the same sex
(D) Paratypes are later collections; syntypes are from the original author

2003

34. Under which specific circumstance is a neotype validly designated?
(A) An author provides a better-preserved specimen than the existing holotype
(B) A new subspecies is described from a different geographical location
(C) Original type material is lost or destroyed and a standard is needed
(D) Male specimens are discovered for a species described only from females

NODIA

2021

35. Consider the following statements regarding nematode taxonomic typification:
I. An allotype is a paratype of the opposite sex to the holotype.

II. A lectotype is designated from syntypes subsequent to the original description.
III. A topotype has official standing as a name-bearing type under the ICZN.

Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II, and III

2017

36. Which statement accurately describes a paralectotype?
(A) A specimen collected alongside the neotype
(B) A morphological variant of the holotype
(C) A type specimen preserved exclusively on a molecular slide
(D) Any remaining syntype specimen after a lectotype has been formally designated

2001

37. De Man's index a in nematode morphometrics is calculated using which formula?
(A) Total body length divided by esophageal length
(B) Total body length divided by maximum body width
(C) Total body length divided by tail length
(D) Tail length divided by anal body width

2025

38. Which morphological characteristic is evaluated by De Man's index c'?
(A) The position of the vulva relative to total body length
(B) The ratio of the stoma length to the esophageal length
(C) The ratio of tail length to the anal body width
(D) The percentage of the gonad length relative to total body length

2013

39. In nematode morphometrics, what does the $V\%$ index represent?
(A) The volume of the pseudocoelom expressed as a percentage
(B) The ratio of the vas deferens length to the total body length
(C) The velocity of movement under standardized conditions
(D) The distance to the vulva as a percentage of total body length

2015

40. Which factor most commonly limits the diagnostic reliability of De Man's indices in nematology?
(A) Allometric growth causes ratios to vary between juveniles and adults
(B) Total body length often shrinks symmetrically during chemical fixation
(C) Indices cannot be calculated for the male nematode specimens
(D) Modern microscopes cannot measure dimensions accurately enough for formulas

2012

41. If a nematode has a total length of 1000 μm and a tail length of 50 μm, what is the value of De Man's index c?
(A) 0.05
(B) 20
(C) 50
(D) 950

2014

42. In Cobb's formula for morphometric representation, how are the measurements arrayed?
(A) As absolute lengths in micrometers from the tail to the head
(B) As percentages of body length to specific structural landmarks
(C) As ratios strictly comparing width to length
(D) As volumetric estimates of major internal organs

2017

43. Which pair of morphometric indices is most critical for differentiating closely related species within the genus Xiphinema?
(A) Odontostylet length and $V\%$
(B) Spicule length and bursa shape
(C) Rennette cell volume and c ratio
(D) Number of incisures and a ratio

2008

44. What was the primary morphological basis for Chitwood's separation of the Class Secernentea from Adenophorea?
(A) The distinct morphology of the stoma
(B) The structural variation in the female reproductive system
(C) The presence or absence of phasmids (caudal sensory organs)
(D) The specific type of somatic musculature

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2021

45. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): The classical division of Nematoda into Adenophorea and Secernentea is no longer supported as completely monophyletic by modern molecular phylogenies.
Reason (R): Molecular data, primarily SSU rDNA, indicates that Secernentea is actually a derived clade nested within the paraphyletic Adenophorea.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

46. Under the modern molecular framework based on small subunit (SSU) rDNA, Phylum Nematoda is broadly divided into which two main classes?
(A) Secernentea and Chromadorea
(B) Enoplea and Adenophorea
(C) Chromadorea and Enoplea
(D) Dorylaimea and Rhabditea

2013

47. Which nematode order, previously placed in Adenophorea, remains a key basal group in the modern Class Enoplea?
(A) Rhabditida
(B) Dorylaimida
(C) Tylenchida
(D) Aphelenchida

2012

48. In modern phylogeny, the plant-parasitic order Tylenchida is classified within which broader molecular clade?
(A) Clade I (Dorylaimia)
(B) Clade III (Spirurina)
(C) Clade II (Enoplia)
(D) Clade XII (Tylenchomorpha / Chromadorea)

2010

49. What advantage does the SSU (18S) rRNA gene provide for reconstructing deep nematode phylogenies?
(A) Conserved regions mixed with variable regions for evolutionary comparison
(B) Extremely rapid evolution ideal for species-level differentiation
(C) Direct coding for cuticular proteins that reflect adaptations
(D) Exclusive presence in free-living nematodes simplifying analyses

2003

50. Consider the following statements regarding classical vs. modern nematode phylogeny:
I. Adenophorea typically possess a highly developed excretory system with lateral canals.
II. Secernentea generally lack amphids but possess phasmids.
III. Modern phylogenetics places Rhabditida and Tylenchida in the same major class (Chromadorea).
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) III only

2010

51. Which molecular target is most widely adopted as the standard "DNA barcode" for animal species, including nematodes?
(A) Cytochrome c oxidase subunit I (COI)
(B) Internal Transcribed Spacer 1 (ITS1)
(C) Large subunit (28S) rRNA
(D) Heat shock protein 90 (HSP90)

2001

52. Why is the Internal Transcribed Spacer (ITS) region frequently preferred over 18S rDNA for differentiating closely related root-knot nematode (Meloidogyne) species?
(A) ITS is highly conserved and shows no intraspecific variation
(B) ITS is a protein-coding gene that directly dictates host range
(C) ITS is located in the mitochondrial genome, preventing recombination
(D) ITS evolves faster, providing resolution for species diagnostics

2006

53. Which PCR-based technique utilizes restriction enzymes to digest amplified DNA into species-specific banding patterns?
(A) Real-Time PCR (qPCR)
(B) Restriction Fragment Length Polymorphism (PCR-RFLP)
(C) Random Amplified Polymorphic DNA (RAPD)
(D) Amplified Fragment Length Polymorphism (AFLP)

NODIA

2025

54. In nematode molecular taxonomy, what is the primary function of species-specific primers?
(A) To amplify the entire genomic DNA sequence of a target nematode
(B) To digest specific genomic regions for Southern blotting
(C) To selectively amplify DNA from a target species in a mixed sample
(D) To sequence the RNA transcriptome during infection

2008

55. Consider the following statements regarding molecular tools in nematology:
I. D2-D3 expansion segments of the 28S rRNA gene are useful for genus and species level identification.
II. DNA barcoding using COI is entirely ineffective due to extreme primer mismatch in all nematodes.
III. Multiplex PCR allows simultaneous detection of multiple nematode species in a single reaction.
IV. Mitochondrial genomes of nematodes are significantly larger than their nuclear genomes.
V. qPCR can provide both identification and absolute quantification of nematodes in a revelation soil sample.
Which of the above statement(s) is/are correct?
(A) I, II, and IV
(B) I, III, and V
(C) II, III, and V
(D) I, IV, and V

2012

56. Which of the following best explains why sequencing the mitochondrial cytochrome oxidase I (COI) gene is sometimes challenging in nematodes?
(A) High substitution rates often cause standard universal primers to fail
(B) Nematodes completely lack mitochondrial DNA sequences
(C) The COI gene is located on an unstable extrachromosomal plasmid
(D) Mitochondrial DNA is rapidly degraded after the nematode dies

2011

57. What is the fundamental biochemical composition of the nematode cuticle?
(A) Exclusively cross-linked chitin fibrils
(B) Structural proteins such as collagens and specialized cuticlins
(C) Purely a matrix of sulfated glycosaminoglycans
(D) Predominantly complex plant-derived lignocelluloses

2009

58. Which specific layer of the nematode cuticle is responsible for conferring the characteristic selective permeability and environmental resistance?
(A) Endocuticle
(B) Epicuticle
(C) Mesocuticle
(D) Exocuticle

2023

59. The structural integrity and flexibility of the nematode cuticle are primarily maintained by which molecular mechanism?
(A) Extensive disulfide cross-linking of collagen trimers
(B) Covalent bonding of chitin monomers
(C) Calcification of the exocuticle
(D) Hydraulic swelling of the endocuticle

2009

60. During the process of moulting (ecdysis) in nematodes, what happens to the old cuticle?
(A) It is absorbed into the hypodermis to recycle nutrients
(B) It remains intact and expands continuously during growth
(C) Inner layers are enzymatically dissolved and the outer is shed
(D) It is incorporated entirely into the new epicuticle

2012

61. Which specialized cellular structure is directly responsible for synthesizing and secreting the layers of the new cuticle during moulting?
(A) The longitudinal somatic muscles
(B) The intestinal epithelial cells
(C) The coelomocytes
(D) The hypodermis (epidermis)

2022

62. Which structural feature characterizes the mesocuticle in many large nematodes (e.g., Ascaris)?
(A) A single homogeneous lipid layer
(B) A dense layer of fluid-filled vacuoles
(C) Spirally arranged, intersecting collagenous fibers
(D) A rigid lattice of calcified spicules

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2012

63. What are the transverse cuticular striations that give some nematodes a superficially segmented appearance called?
(A) Incisures
(B) Annulations
(C) Areolations
(D) Punctations

2011

64. Lateral fields (incisures) are longitudinal cuticular markings. What is their presumed primary biological function?
(A) To harbor symbiotic bacteria
(B) To act as the site for gas exchange
(C) To secrete sex pheromones in males
(D) To permit expansion during feeding or body flexure

2014

65. When transverse cuticular annulations cross the longitudinal lines of the lateral field, the resulting block-like pattern is termed:
(A) Areolation
(B) Punctation
(C) Tessellation
(D) Fenestration

2002

66. Which favourable cuticular surface modification appears as minute, distinct dot-like depressions or structures often arranged in precise patterns?
(A) Longitudinal striae
(B) Alae
(C) Punctations
(D) Incisures

2002

67. The prominent wing-like cuticular expansions found along the lateral sides of some nematodes, particularly in the cervical or caudal regions, are known as:
(A) Alae
(B) Annules
(C) Phasmids
(D) Deirids

2001

68. Which cuticular adaptation is commonly utilized in the taxonomic identification of Heterodera cysts?
(A) The exact number of longitudinal incisures
(B) The specific color of the mesocuticle
(C) The width of the cervical alae
(D) Patterns of perineal punctations and vulval fenestrae

2015

69. Based on the arrangement of somatic musculature, what defines a "holomyarian" nematode?
(A) There are exactly two to four massive muscle cells per quadrant
(B) Muscle cells form a continuous layer not interrupted by hypodermal chords
(C) Muscle cells are absent, relying solely on hypodermal contractions
(D) There are numerous closely packed muscle cells in each quadrant

2010

70. How is a "polymyarian" muscle arrangement distinguished morphologically?
(A) A few broad muscle cells in each interchordal zone
(B) Complete absence of longitudinal muscles
(C) Numerous muscle cells projecting into the pseudocoelom
(D) Striated circular muscles dominating the body wall

2015

71. In typical meromyarian nematodes, how many somatic muscle cells are usually present between the dorsal/ventral and lateral chords?
(A) 10 to 20 cells
(B) More than 50 cells
(C) None, they are entirely acontractile
(D) 2 to 5 cells

2018

72. Which portion of a nematode somatic muscle cell extends to contact the longitudinal nerve cords for innervation?
(A) The non-contractile muscle arm or innervation process
(B) The contractile fibrillar zone
(C) The specialized myoblast nucleus
(D) The syncytial hypodermal layer

2015

73. What characterizes the functional contraction of nematode longitudinal muscles?
(A) Synchronous contraction along the body for telescoping
(B) Alternating dorsal/ventral contractions for undulatory waves
(C) Radial contraction to increase pseudocoelomic volume
(D) Lateral bending without dorsal or ventral involvement

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2012

74. Which specialized musculature is strictly independent of the main somatic longitudinal musculature in nematodes?
(A) The cephalic retractors
(B) The pharyngeal (esophageal) musculature
(C) The labial papillae
(D) The tail tip contractility complex

2022

75. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): Nematodes must rely strictly on dorso-ventral undulatory locomotion rather than peristaltic crawling.
Reason (R): Nematodes entirely lack circular muscle fibers in their body wall, preventing antagonistic circular-longitudinal peristalsis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

76. Amphids are critical sensory organs in nematodes. Where are they anatomically located?
(A) In the caudal region, near the tail tip
(B) Ventrally, just posterior to the excretory pore
(C) Laterally in the cephalic (head) region
(D) Dorsally, adjacent to the pharyngeal bulb

2002

77. What is the primary functional role of the amphids?
(A) Purely mechanoreception for soil particles
(B) Photoreception via specialized opsin proteins
(C) Osmoregulation by expelling excess water
(D) Chemoreception for host and pheromone location

2011

78. Which sensory structures are functionally analogous to amphids but are located in the posterior (tail) region of Secernentea nematodes?
(A) Deirids
(B) Hemizonids
(C) Phasmids
(D) Cephalids

2005

79. The deirids are small, paired sensory papillae found in many nematodes. Where are they typically situated?
(A) Near the vulva in adult females
(B) In the lateral fields near the level of the nerve ring
(C) On the lips surrounding the oral opening
(D) At the terminus of the male spicules

2009

80. Arrange the following structures of a typical plant-parasitic nematode in sequential order from anterior to posterior.
1. Nerve ring
2. Stylet
3. Median bulb
4. Basal bulb

(A) 2 - 1 - 3 - 4
(B) 2 - 3 - 1 - 4
(C) 2 - 3 - 4 - 1
(D) 1 - 2 - 3 - 4

2015

81. The hemizonid is a distinct lenticular structure found in many nematodes. What is its anatomical nature?
(A) A nerve commissure located ventrally near the excretory pore
(B) A cuticular pore for the release of pheromones
(C) A muscular valve regulating intestinal emptying
(D) A specialized reproductive gland

2024

82. Which of the following best describes a stomatostylet?
(A) A solid, tooth-like spear derived from the esophageal wall
(B) A ventrally curved tooth used exclusively for predatory slashing
(C) A hollow spear formed from fused, cuticularized stoma walls
(D) An extrudable radula used for scraping fungal hyphae

2005

83. The odontostylet, characteristic of Order Dorylaimida, originates from which embryonic tissue?
(A) The anterior esophageal wall (sub-cuticular origin)
(B) The subventral pharyngeal gland cell
(C) The stomatal wall itself
(D) The mid-gut epithelium

NODIA

2005

84. How does an onchiostylet fundamentally differ from an odontostylet?
(A) An onchiostylet is hollow and functions like a needle
(B) An onchiostylet possesses prominent basal knobs
(C) An onchiostylet penetrates bacterial cell walls
(D) A solid curved tooth with a guide tube in Trichodoridae

2008

85. Match the stylet type or feeding apparatus in List I with the representative nematode group in List II.
List I: (Stylet Type)
P. Stomatostylet
Q. Odontostylet
R. Onchiostylet
S. Rhabditoid stoma (no stylet)
List II: (Nematode Group)
1. Trichodorus
2. Caenorhabditis
3. Heterodera
4. Xiphinema
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

2007

86. Which structural component of the stomatostylet serves as the primary attachment point for the protractor muscles?
(A) The conical anterior tip (cone)
(B) The cylindrical shaft
(C) The basal knobs
(D) The guiding ring

2011

87. A tylenchoid esophagus is classically characterized by the presence of:
(A) A narrow corpus, lacking a median bulb, and a massive distinct basal bulb
(B) A completely cylindrical pharynx lacking any bulbs or valves
(C) A short anterior muscular section and a long capillary-like tube (stichosome)
(D) A metacorpus with valve plates, an isthmus, and a basal bulb

2006

88. How does an aphelenchoid esophagus structurally differ from a tylenchoid esophagus?
(A) The dorsal gland opens into the median bulb anterior to the valve
(B) It lacks a median bulb entirely
(C) The basal bulb is heavily muscular rather than glandular
(D) It possesses an inverted stoma lacking any stylet structure

2011

89. Which characteristic defines a dorylaimoid esophagus?
(A) A highly distinct median bulb with a crescentic valve
(B) A slender anterior part and an expanded posterior cylinder
(C) A two-part pharynx where the posterior part consists of stichocytes
(D) The complete absence of an isthmus and connection to the cloaca

2003

90. Which esophageal type is characterized by a "dumb-bell" shape consisting of a corpus, a narrow isthmus, and a basal bulb containing a complex "butterfly" valve?
(A) Tylenchoid
(B) Rhabditoid
(C) Aphelenchoid
(D) Diplogasteroid

2005

91. In a typical plant-parasitic nematode, the secretions from the esophageal glands are primarily responsible for:
(A) Extra-corporeal digestion and host cell modification
(B) Forming the hard cuticular structures of the eggshell
(C) Lubricating the movement of the spicules during copulation
(D) Regulating the internal osmotic pressure of the pseudocoelom

2002

92. The secretory-excretory (S-E) system in Secernentea is typically characterized by which morphology?
(A) A purely glandular system consisting of a single massive ventral cell
(B) An extensive network of ciliated flame cells
(C) A tubular system with H-shaped or inverted lateral canals
(D) Completely absent, utilizing cuticular diffusion exclusively

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2016

93. What is the fundamental structure of the excretory system in most Adenophorean nematodes?
(A) A complex tubular network spanning the body
(B) Multiple protonephridia discharging directly through the cuticle
(C) A specialized malpighian tubule system emptying into the hindgut
(D) A single ventral rennette cell lacking lateral canals

2004

94. What is the primary proposed physiological function of the nematode S-E system?
(A) Digestion of complex host lipids
(B) Pumping oxygen into the pseudocoelomic fluid
(C) Osmoregulation and secretion of specialized glycoproteins
(D) Production and storage of developing oocytes

2009

95. In the female reproductive system, what does the term "monodelphic" indicate?
(A) The presence of two opposing ovaries
(B) The presence of a single ovary/genital tract
(C) The complete fusion of the male and female reproductive systems
(D) The continuous production of unfertilized, viable eggs (parthenogenesis)

2009

96. A female nematode possessing two genital tracts extending in opposite directions from the vulva is described as:
(A) Monodelphic prodelphic
(B) Didelphic opisthodelphic
(C) Monorchic
(D) Didelphic amphidelphic

2001

97. The specialized expanded sac in the female genital tract where sperm is stored prior to fertilization is called the:
(A) Spermatheca
(B) Oviduct
(C) Uterus
(D) Vagina

2011

98. What structural arrangement characterizes a "prodelphic" reproductive system?
(A) The ovary and genital tract extend posteriorly from the vulva
(B) The reproductive tract loops around the intestine multiple times
(C) The ovary and genital tract extend anteriorly from the vulva
(D) The system lacks a defined vulva, releasing eggs by uterine rupture

2015

99. Which of the following is true regarding male nematode reproductive systems?
(A) Testes emptying into a common cloaca with the digestive tract
(B) They frequently possess an ovipositor for sperm transfer
(C) Their testes open through a separate genital pore distinct from the anus
(D) Sperm transfer occurs exclusively via an open spermatophore packet

2012

100. Select the correct sequence of structures in the female nematode reproductive tract, proceeding outward from the site of oocyte production.
(A) Ovary → Spermatheca → Oviduct → Uterus → Vagina
(B) Ovary → Oviduct → Spermatheca → Uterus → Vagina
(C) Uterus → Spermatheca → Oviduct → Ovary → Vagina
(D) Spermatheca → Ovary → Uterus → Oviduct → Vagina

NODIA

2006

101. What does the term "monorchic" refer to in male nematodes?
(A) The presence of a single spicule
(B) The presence of a single testis
(C) The ability to self-fertilize as a hermaphrodite
(D) The lack of a gubernaculum

2013

102. Spicules are the primary copulatory organs in male nematodes. What is their function?
(A) To synthesize and secrete seminal fluid
(B) To act as external claspers wrapped around the female body
(C) To penetrate the female vulva and hold it open for sperm transfer
(D) To produce pheromones that attract receptive females

2003

103. What is the gubernaculum in the male reproductive anatomy?
(A) A glandular sac producing sperm

(B) An expanded cuticular wing used for gripping the female
(C) The terminal exit pore for both feces and sperm
(D) A sclerotized trough structure that guides the spicules

2015

104. How does a "peloderan" bursa structurally differ from a "leptoderan" bursa in male nematodes?
(A) A peloderan bursa encloses the tail; leptoderan leaves it free
(B) A peloderan bursa is absent, while a leptoderan bursa is massive
(C) A peloderan bursa is muscular, whereas leptoderan is cuticular
(D) A peloderan bursa has spicules, whereas leptoderan lacks them

2013

105. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): Nematode sperm cells are structurally unique because they lack flagella.
Reason (R): They utilize amoeboid movement mediated by Major Sperm Protein (MSP) to crawl toward the oocyte.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

106. During early nematode embryogenesis, what type of cleavage pattern is characteristically observed?
(A) Spiral cleavage
(B) Modified bilateral or strictly determinate cleavage
(C) Radial indeterminate cleavage
(D) Superficial cleavage

2024

107. Which specific early embryonic cell lineage gives rise exclusively to the nematode's germ line?
(A) The P cell lineage (specifically P4)
(B) The AB cell lineage
(C) The E cell lineage
(D) The MS cell lineage

2017

108. In typical nematode development, how many juvenile stages follow hatching before adulthood is reached?
(A) Two
(B) Three
(C) Four
(D) Five

2005

109. Where does the first moult (from J1 to J2) commonly occur in endoparasitic plant nematodes like Meloidogyne and Heterodera?
(A) Ex ovum, in the soil solution
(B) Ex ovum, within the host plant root
(C) Inside the maternal uterus prior to egg laying
(D) In ovum, before the juvenile hatches from the egg

2012

110. Arrange the following developmental stages of Meloidogyne incognita in correct chronological order.
1. Adult female establishes feeding site
2. J2 penetrates the root elongation zone
3. First moult (J1 to J2) occurs
4. Deposition of eggs in a gelatinous matrix
(A) 3 - 2 - 1 - 4
(B) 2 - 3 - 1 - 4
(C) 3 - 1 - 2 - 4
(D) 2 - 1 - 3 - 4

2019

111. Which phenomenon defines "eutely" in adult nematodes?
(A) The capacity to continuously regenerate lost body parts
(B) Cessation of cell division leading to a fixed cell number
(C) The ability to undergo indefinite rounds of moulting throughout adulthood
(D) The simultaneous maturation of both sperm and ova in a single individual

2015

112. The specialized "dauer juvenile" stage is primarily formed in response to which environmental conditions?
(A) Ideal temperature and excess food availability
(B) Complete immersion in a liquid medium
(C) Exposure to specific chemical nematicides
(D) Overcrowding, pheromones, and food scarcity

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2017

113. In which developmental stage does the classic Caenorhabditis elegans typically enter the diapause-like dauer state?
(A) J3
(B) J1
(C) J2
(D) J4

2016

114. Which structural adaptation is highly characteristic of a dauer juvenile, facilitating its survival?
(A) An actively feeding, hypertrophied pharynx
(B) The precocious development of functional reproductive organs
(C) A thickened cuticle and closure of the oral opening
(D) Complete shedding of the epicuticle to increase water absorption

2002

115. Consider the following statements regarding nematode embryogenesis:
I. Nematode development typically exhibits determinate cleavage.
II. The E blastomere lineage gives rise primarily to the gut.
III. In most plant-parasitic species, the J1 stage actively feeds on root hairs before moulting.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

2025

116. Which plant-parasitic nematode genus is characterized by having females that become swollen, sedentary cysts retaining their eggs after death?
(A) Meloidogyne
(B) Pratylenchus
(C) Radopholus
(D) Heterodera

2011

117. What is the primary infective stage of the root-knot nematode, Meloidogyne?
(A) The adult male
(B) The second-stage juvenile (J2)
(C) The first-stage juvenile (J1)
(D) The embryonated egg

2004

118. Which structural feature in adult Meloidogyne females specifically distinguishes them from Heterodera females?
(A) Meloidogyne females transform into hard, tanned cysts
(B) Meloidogyne females have a lemon shape with a prominent vulval cone
(C) External gelatinous matrix egg deposition instead of cyst retention
(D) Meloidogyne females possess a highly robust, dorylaimoid odontostylet

2023

119. The root-lesion nematodes belong to which economically important genus?
(A) Radopholus
(B) Rotylenchulus
(C) Helicotylenchus
(D) Pratylenchus

NODIA

2006

120. Which feature is highly diagnostic for identifying species within the genus Pratylenchus?
(A) The number of lip annules and the shape of the tail terminus
(B) The presence of a prominent peloderan bursa in females
(C) The formation of multinucleate giant cells in host roots
(D) The size and calcification of the cyst wall

2011

121. The burrowing nematode, Radopholus similis, exhibits significant sexual dimorphism. Which description matches this dimorphism?
(A) Males are swollen and sedentary; females are vermiform and motile
(B) Females completely lack a stylet and absorb nutrients through the cuticle
(C) Males possess a functional odontostylet whereas females have a stomatostylet
(D) Males possess a degenerate stylet and are non-feeding

2003

122. Which genus is known as the "reniform nematode" due to the characteristic kidney-like shape of the mature female?
(A) Tylenchulus
(B) Rotylenchulus
(C) Hoplolaimus
(D) Globodera

2001

123. Where do the mature females of Rotylenchulus reniformis typically position themselves during feeding?
(A) Semi-endoparasitically with the posterior body outside
(B) Completely embedded within the root cortex
(C) Strictly ectoparasitically, feeding entirely on external root hairs
(D) Freely motile within the soil matrix, feeding transiently on multiple roots

2002

124. The citrus nematode, Tylenchulus semipenetrans, typically secretes which structural matrix to protect its eggs?
(A) A tough cuticular cyst
(B) A calcified external shell
(C) A gelatinous matrix incorporating soil particles
(D) A silken cocoon produced by the excretory pore

2011

125. Which diagnostic morphological feature characterizes the genus Helicotylenchus?
(A) A perfectly straight, rigid body posture when heat-killed
(B) A heavily segmented, caterpillar-like cuticle
(C) The presence of massive, spear-like spicules in the female
(D) Spiral body posture when relaxed and a short tail

2024

126. The lance nematodes belong to which of the following genera?
(A) Belonolaimus
(B) Criconemoides
(C) Hoplolaimus
(D) Xiphinema

2012

127. Which feature is prominent and diagnostic for the genus Hoplolaimus?
(A) Extremely long, flexible stylet exceeding 100 micrometers
(B) Stylet with tulip-shaped knobs and overlapping glands
(C) Complete absence of a median bulb
(D) A strictly sedentary endoparasitic lifestyle

2018

128. What cuticular characteristic makes the ring nematodes (Criconematidae) morphologically unique?
(A) A perfectly smooth cuticle lacking any annulations
(B) A cuticle covered entirely in dense, hair-like setae
(C) A highly calcified, shell-like outer layer
(D) Deep, retrorse annulations often with crenate margins

2018

129. How do ring nematodes (e.g., Criconemoides) primarily maneuver through the soil given their unique body plan?
(A) Sluggish contractions using the annulated cuticle for traction
(B) By rapid, snake-like undulations
(C) By utilizing flagellated epithelial cells
(D) They are completely immobile and rely on water currents

2011

130. The genus Aphelenchoides primarily encompasses species known by which common name?
(A) Root-knot nematodes
(B) Cyst nematodes
(C) Foliar/leaf nematodes
(D) Dagger nematodes

2012

131. Which feeding habit is characteristic of many Aphelenchoides species?
(A) Feeding on leaf mesophyll and many are also fungivorous
(B) They are strict, obligate sedentary root parasites
(C) They specialize exclusively in feeding on deep woody xylem tissues
(D) They prey on other soil nematodes using a massive stomatostylet

2012

132. How can the genus Aphelenchoides be distinctly separated from Aphelenchus?
(A) Aphelenchoides has a distinct median bulb, while Aphelenchus lacks one
(B) Aphelenchoides has a tylenchoid esophagus, whereas Aphelenchus has a dorylaimoid one
(C) Aphelenchoides is strictly a root parasite, while Aphelenchus only attacks stems
(D) Aphelenchoides lacks a bursa, while Aphelenchus possesses one

2009

133. The pine wood nematode, a highly destructive pathogen of forestry, belongs to which genus?
(A) Rhadinaphelenchus
(B) Bursaphelenchus

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(C) Ditylenchus
(D) Xiphinema

2009

134. What is the primary vector mechanism for the transmission of Bursaphelenchus xylophilus in nature?
(A) Soil water splashing onto lower branches
(B) Wind-blown dispersal of resting cysts
(C) Transportation by longhorn beetles (genus Monochamus)
(D) Transport through the digestive tracts of migratory birds

2019

135. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): Bursaphelenchus xylophilus utilizes an insect vector to reach new host trees.
Reason (R): It forms a specialized dispersal stage (J4) that enters the tracheal system of the emerging adult beetle.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

136. Which diagnostic feature is typically prominent in female Bursaphelenchus species?
(A) A characteristic vulval flap covering the genital pore
(B) A swollen, pear-shaped body upon maturation
(C) The presence of dual, opposing reflexed ovaries
(D) The complete fusion of the stylet knobs into a single disc

2005

137. Which nematode order is characterized by possessing a two-part esophagus (slender anterior, expanded muscular/glandular posterior) and a specialized hollow stylet called an odontostylet?
(A) Tylenchida
(B) Dorylaimida
(C) Rhabditida
(D) Triplonchida

2024

138. The dagger nematodes, known vectors of nepoviruses, belong to which genus?
(A) Longidorus
(B) Xiphinema
(C) Trichodorus
(D) Paratrichodorus

2021

139. How does the odontostylet of Xiphinema fundamentally differentiated from the stylet of Longidorus?
(A) Xiphinema has flanged extensions; Longidorus lacks true flanges
(B) Xiphinema has a short, solid tooth, while Longidorus has a hollow needle
(C) Xiphinema stylets are curved ventrally, while Longidorus stylets are strictly straight
(D) Xiphinema stylets are shed during every moult, whereas Longidorus stylets are permanent

2015

140. Where is the guiding ring situated in the stoma of Xiphinema compared to Longidorus?
(A) Posterior in Xiphinema, and near the anterior tip in Longidorus
(B) Near the anterior tip in Xiphinema, and near the base in Longidorus
(C) It is entirely absent in Xiphinema
(D) It forms a double ring structure exclusively in Longidorus

2025

141. Needle nematodes, which are highly destructive ectoparasites, belong to the genus:
(A) Belonolaimus
(B) Xiphinema
(C) Paratylenchus
(D) Longidorus

NODIA

2005

142. The stubby-root nematodes are primarily represented by which two related genera?
(A) Xiphinema and Longidorus
(B) Pratylenchus and Radopholus
(C) Trichodorus and Paratrichodorus
(D) Meloidogyne and Nacobbus

2009

143. Which taxonomic order accommodates the stubby-root nematodes?
(A) Dorylaimida
(B) Tylenchida
(C) Mononchida
(D) Triplonchida

2021

144. What type of feeding apparatus is specifically found in the genera Trichodorus and Paratrichodorus?
(A) A highly robust stomatostylet
(B) A hollow odontostylet identical to Xiphinema
(C) A cutting buccal cavity lined with denticles
(D) A solid, curved, dorsally grooved onchiostylet

2002

145. Match the nematode genus in List I with its transmitted plant virus group in List II.
List I: (Nematode Genus)
P. Xiphinema
Q. Longidorus
R. Trichodorus
S. Paratrichodorus
List II: (Plant Virus Group)
1. Nepoviruses (e.g., Tomato black ring virus)
2. Nepoviruses (e.g., Grapevine fanleaf virus)
3. Tobraviruses (e.g., Tobacco rattle virus)
4. Tobraviruses (e.g., Pea early-browning virus)
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2007

146. How do stubby-root nematodes utilize their onchiostylet during feeding?
(A) They forcefully inject digestive enzymes deep into the vascular cylinder
(B) They slash the epidermis and absorb the entire resulting sap flow externally
(C) Puncturing outer root cells creating a tube of secretions
(D) They embed it permanently into a single giant cell

2003

147. What primary morphological feature separates Paratrichodorus from Trichodorus?
(A) Posterior cuticle swells on fixation in Paratrichodorus
(B) Paratrichodorus has an onchiostylet, while Trichodorus has an odontostylet
(C) Paratrichodorus females are strictly monodelphic, while Trichodorus are didelphic
(D) Paratrichodorus is a root-knot former, while Trichodorus is ectoparasitic

2015

148. Which characteristic distinguishes the musculature of the pharyngeal basal bulb in Dorylaimida?
(A) It lacks muscle fibers completely and is purely glandular
(B) It consists exclusively of circular sphincter muscles
(C) It is replaced entirely by a stichosome
(D) It contains prominent radial muscle fibers allowing it to function as a powerful pump

2015

149. The process of stylet replacement during moulting in Dorylaimida involves:
(A) The complete resorption of the old stylet into the intestinal tract
(B) Replacement odontostylet formation in the anterior esophagus
(C) The synthesis of a new stylet exclusively from the shed cuticular layers
(D) The continuous elongation of the original stylet without replacement

2025

150. Which of the following gnera is known for inducing characteristic terminal galls on roots due to feeding on meristematic tissue?
(A) Pratylenchus
(B) Aphelenchoides
(C) Xiphinema
(D) Trichodorus

2022

151. The stem and bulb nematode, which heavily damages crops like onions and garlic, belongs to which genus?
(A) Anguina
(B) Heterodera
(C) Nacobbus
(D) Ditylenchus

2002

152. What is a key survival adaptation of Ditylenchus dipsaci under extreme desiccation?
(A) Forming "nematode wool" resistant to anhydrobiosis
(B) Forming a heavily calcified external cyst
(C) Retreating to groundwater tables deep below the soil surface
(D) Entering a symbiotic state within fungal spores

NODIA

2011

153. The genus Anguina is classically known for primarily attacking which part of the host plant?
(A) Deep taproots
(B) Woody xylem vessels
(C) The root cortex exclusively
(D) Seed heads and foliage, forming distinct galls

2018

154. What vector relationship is significantly associated with Anguina tritici?
(A) It transmits Grapevine fanleaf virus to adjacent crops
(B) Carrying Clavibacter bacteria causing yellow ear rot
(C) It acts as a passive vector for Fusarium oxysporum
(D) It requires aphid transmission to reach the seed heads

2021

155. Consider the following statements regarding the genus Nacobbus (False root-knot nematode):
I. It induces galls on host roots superficially resembling Meloidogyne damage.
II. Unlike Meloidogyne, the mature female retains a vermiform anterior portion while the posterior is swollen.
III. It produces a specialized lemon-shaped cyst upon death.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II, and III

2001

156. In systematic classification, which morphological feature places Nacobbus within the family Pratylenchidae rather than Meloidogynidae?
(A) The presence of dual functional ovaries
(B) The complete absence of a gelatinous egg sac
(C) Morphological traits typical of root-lesion nematodes
(D) The lack of any gall-inducing capacity

2025

157. The pin nematodes are tiny, mostly ectoparasitic nematodes belonging to the genus:
(A) Rotylenchulus
(B) Scutellonema
(C) Tylenchorhynchus
(D) Paratylenchus

2005

158. Which exceptional morphological trait is frequently observed in the genus Paratylenchus?
(A) A massive, heavily cuticularized stoma lacking a stylet
(B) Complete loss of the intestinal tract in adult females
(C) An extraordinarily long stylet in relation to its small body size
(D) The presence of three functioning ovaries

2007

159. The stunt nematodes are characterized by a well-developed, heavily sclerotized cephalic framework and typically have a blunt tail. They belong to which genus?
(A) Heterodera
(B) Tylenchorhynchus
(C) Aphelenchus
(D) Hemicycliophora

2019

160. Which genus is known as the "sheath nematode" due to the retention of the extra cuticular layer from the last juvenile moult?
(A) Criconemoides
(B) Paratrichodorus
(C) Belonolaimus
(D) Hemicycliophora

2012

161. The genus Globodera was historically separated from Heterodera. What is the primary morphological distinction between their mature cysts?
(A) Globodera is spherical; Heterodera has a vulval cone
(B) Globodera cysts are uniquely lemon-shaped, while Heterodera are spherical
(C) Globodera cysts are smooth, whereas Heterodera cysts possess thick spines
(D) Globodera cysts release all eggs continuously, whereas Heterodera retains them

2015

162. The golden potato cyst nematode is scientifically named:
(A) Globodera pallida
(B) Heterodera avenae
(C) Globodera rostochiensis
(D) Heterodera glycines

2007

163. How is the species Globodera pallida distinguished visually from G. rostochiensis during its development on the host root?
(A) G. pallida stays white; G. rostochiensis turns golden
(B) G. pallida cysts turn dark red, while G. rostochiensis turn blue
(C) G. pallida produces exclusively male offspring in high-density conditions
(D) G. pallida never forms a rigid cyst wall

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2010

164. What specialized root cellular structure is induced and maintained by feeding Heterodera and Globodera species?
(A) Discrete, highly separated uninucleate giant cells formed by karyokinesis without cytokinesis
(B) Hyperplastic gall tissue completely lacking specialized feeding cells
(C) Purely necrotic lesions that provide degraded nutrients
(D) Multinucleate syncytia formed by cell wall dissolution

2010

165. Consider the following statements concerning Meloidogyne biology:
I. Feeding induces the formation of discrete multinucleate giant cells via repeated mitosis without cell division.
II. Sex determination is strictly environmental; adverse conditions favor male development.
III. All Meloidogyne species reproduce exclusively by obligate amphimixis (sexual reproduction).
IV. The J2 stage actively penetrates behind the root tip and migrates intercellularly.
Which of the above statement(s) is/are correct?
(A) I, II, and IV
(B) I, III, and IV
(C) II, III, and IV
(D) I, II, and III

2006

166. Which Meloidogyne species is globally recognized as the most damaging and widely distributed root-knot nematode in tropical and subtropical agriculture?
(A) Meloidogyne hapla
(B) Meloidogyne chitwoodi
(C) Meloidogyne incognita
(D) Meloidogyne naasi

2023

167. Which specific biochemical structure is secreted from the excretory pore of Meloidogyne females to encapsulate and protect their eggs?
(A) A chitinous hard shell
(B) A pure lipid bilayer
(C) A rigid cyst derived from the cuticle
(D) A gelatinous matrix of cross-linked glycoproteins

2010

168. The "northern root-knot nematode," adapted to cooler climates and uniquely characterized by a small, distinct perineal pattern, is:
(A) Meloidogyne hapla
(B) Meloidogyne arenaria
(C) Meloidogyne incognita
(D) Meloidogyne javanica

2007

169. What is a "perineal pattern" in the context of root-knot nematode diagnostics?
(A) The specific feeding pattern observed on the host root system
(B) The branching structure of the female reproductive tract
(C) The internal layout of the pharyngeal glands
(D) Cuticular striae around the vulva and anus of the female

2004

170. Which diagnostic metric is most frequently used to definitively distinguish Meloidogyne incognita from M. javanica based on the perineal pattern?
(A) The complete absence of cuticular striae in M. incognita
(B) Distinct lateral incisures in the pattern of M. javanica
(C) The massive size of the phasmids in M. incognita
(D) The strictly rectangular shape of the overall pattern in M. javanica

2013

171. In nematode taxonomy, what is a "morphospecies"?
(A) A species delineated strictly by observable morphological and structural features
(B) A species delineated primarily by distinct molecular sequences
(C) A species defined by its ability to interbreed exclusively within its group
(D) A hybrid species displaying intermediate traits

NODIA

2018

172. When describing a new nematode genus, the designated type species must be fixed. Which ICZN principle governs this?
(A) Principle of Homonymy
(B) Principle of Priority
(C) Principle of Typification
(D) Principle of Coordination

2010

173. What is the standard biological function of nematode coelomocytes?
(A) Digestion of structurally complex plant cell walls
(B) Rapid transmission of electrical impulses
(C) Locomotion outside the host organism
(D) Debris removal and internal pressure regulation

2005

174. Which of the following best describes the nematode nerve ring (circumpharyngeal commissure)?
(A) A dispersed network of ganglia located in the tail
(B) A linear cord running the entire ventral length of the body
(C) Central integration center encircling the esophagus
(D) A strictly sensory structure responsive only to light

2012

175. Consider the following statements regarding nematode post-embryonic development:
I. Moulting is triggered by endocrine signals likely involving ecdysone-like sterols.
II. The intermoult period represents periods of rapid exponential cellular division in all tissues.
III. Lethargus is a period of behavioral quiescence immediately preceding the shedding of the old cuticle.
IV. Exsheathment refers to the process of escaping an un-shed retained cuticle.
V. The J4 stage always lacks any reproductive structures.
Which of the above statement(s) is/are correct?
(A) I, II, and III
(B) I, III, and IV
(C) II, IV, and V
(D) I, III, and V

2010

176. Which of the following correctly pairs a nematode feeding behavior with an appropriate genus?
(A) Sedentary endoparasite - Pratylenchus
(B) Sedentary ectoparasite - Meloidogyne
(C) Migratory ectoparasite - Heterodera
(D) Migratory endoparasite - Radopholus

2011

177. The genus Scutellonema is primarily distinguished by the presence of large, shield-like:
(A) Phasmids (scutella)
(B) Amphids
(C) Deirids
(D) Cephalids

2024

178. What morphological feature allows members of the genus Criconemoides to resist tremendous physical crushing pressure in the soil?
(A) A highly calcified internal endoskeleton
(B) A body filled completely with rigid parenchymal cells
(C) Heavily sclerotized retrorse cuticular annulations
(D) The continuous excretion of a solid crystalline matrix

2007

179. In plant pathology, the interaction between Meloidogyne incognita and Fusarium oxysporum is a classic example of:
(A) Synergistic disease complex (nematode-fungus complex)
(B) Antagonism
(C) Predation
(D) Competitive displacement

2016

180. How does nematode feeding typically predispose a host plant to secondary fungal wilt infections?
(A) The nematode directly synthesizes and injects fungal spores
(B) The nematode specifically suppresses the fungus until the plant dies
(C) Nematode excretions act as powerful fungicides that mutate the local fungi
(D) Wounding provides entry pathways and nutrient sinks

2007

181. Which molecular diagnostic target is highly favored for differentiating species within the Bursaphelenchus xylophilus species complex?
(A) Complete chloroplast genome sequencing
(B) Ribosomal DNA ITS regions with restriction digests
(C) Single nucleotide polymorphisms in the hemoglobin gene
(D) Total lipid profiling

2005

182. A major limitation of strictly morphology-based taxonomy in genera like Pratylenchus is:
(A) Extreme sexual dimorphism makes females unrecognizable
(B) They entirely lack a stylet and an esophagus
(C) High intraspecific plasticity blurs species

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boundaries
(D) They cannot be permanently mounted on microscope slides

2011

183. Which statement accurately describes a "cryptic species" in nematology?
(A) A species that hides entirely within host tissues and is never found in soil
(B) A species that lacks a formal Latin name
(C) A life stage that remains completely dormant for decades
(D) Morphologically indistinguishable but genetically divergent

2016

184. The use of specific D2/D3 primer sets in nematode diagnostics primarily targets which genomic component?
(A) The 28S large subunit rRNA gene
(B) The mitochondrial COI gene
(C) The 18S small subunit rRNA gene
(D) The beta-tubulin gene

2024

185. What is the fundamental utility of a "lectotype" in older nematode taxonomy?
(A) To replace a damaged holotype with a freshly collected specimen
(B) To designate a male specimen when only a female holotype exists
(C) To serve as an illustration rather than a physical specimen
(D) To designate a type specimen from original syntypes

2009

186. Which feature characterizes the esophago-intestinal valve (cardia) in nematodes?
(A) It pumps food forcefully into the intestine
(B) It prevents regurgitation of intestinal contents
(C) It synthesizes digestive proteases
(D) It functions as a secondary filter for large soil particles

2009

187. The distinct "metacorpus" in a tylenchoid nematode corresponds to which structure?
(A) The muscular median bulb
(B) The basal glandular bulb
(C) The slender procorpus
(D) The isthmus

2023

188. What is the primary function of the subventral esophageal glands during early nematode infection?
(A) Producing structural proteins for cyst formation
(B) Releasing powerful neurotoxins to paralyze the host plant
(C) Secreting enzymes to facilitate root penetration
(D) Digesting absorbed plant sap purely intra-corporeally

2012

189. During the establishment of a feeding site by a sedentary endoparasite, the dorsal esophageal gland is primarily implicated in:
(A) Synthesizing the tough external cuticle
(B) Breaking down the nematode's own stylet
(C) Producing reproductive pheromones
(D) Effector protein secretion to induce feeding cells

NODIA

2007

190. How does a syncytium, induced by Heterodera, form structurally?
(A) By the rapid enlargement of a single cortical cell without any adjacent involvement
(B) By highly localized, rapid cell division forming a distinct tumor
(C) Cell wall dissolution between adjacent root cells
(D) By the deposition of massive amounts of lignin around a feeding site

2007

191. A giant cell, induced by Meloidogyne, forms structurally through:
(A) The physical fusion of thousands of neighboring cells
(B) Continuous rounds of mitosis uncoupled from cytokinesis within a discrete cell
(C) Invagination of the root epidermis directly into the vascular tissue
(D) The complete halting of all host cell metabolic activity

2005

192. Which metabolic characteristic is universally shared by both syncytia and giant cells?
(A) They are entirely dead, necrotic tissues
(B) They exhibit significantly reduced cytoplasmic density
(C) They possess highly lignified, impermeable secondary cell walls
(D) They are metabolically active sinks with

dense cytoplasm

2022

193. The feeding tubes structurally assembled within the host cell cytoplasm during parasitism by Heterodera are formed from:
(A) Secretions explicitly injected from the nematode's esophageal glands
(B) Host plant cell wall components
(C) Nematode amphidial secretions
(D) Crystallized plant sap

2017

194. In the classical Chitwood system, the presence of well-developed amphids primarily characterized which group?
(A) Only plant-parasitic Secernentea
(B) Exclusively marine Secernentea
(C) Adenophorea
(D) Tylenchida

2003

195. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): Nematode taxonomy heavily relies on electron microscopy for identifying fine cuticular patterns and lip region structures.
Reason (R): Many diagnostically critical features, such as the exact number of labial sectors, are beyond the resolution limits of standard light microscopy.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

196. The specialized "en face" view in nematode morphology refers to:
(A) A longitudinal cross-section of the mid-body
(B) A strictly posterior observation of the tail terminus
(C) The analysis of the lateral fields using scanning electron microscopy
(D) A frontal view of the head to observe lip arrangements

2017

197. According to classical morphology, what is the basic ancestral arrangement of the labial region (lips) in nematodes?
(A) Two massive lateral lips
(B) Six distinct lips (two subdorsal, two lateral, two subventral)
(C) Three bilobed lips
(D) A completely smooth, fused oral disc

2021

198. The term "cephalic framework" refers to:
(A) The neural network comprising the circumpharyngeal ring
(B) The specialized musculature powering the stylet
(C) Sclerotized internal head support in Tylenchida
(D) The cuticular annulations strictly confined to the neck region

2011

199. What does the term "areolation" specifically describe regarding the lateral field?
(A) The complete absence of lateral incisures
(B) The continuous longitudinal splitting of the incisures
(C) The presence of deep, circular pits strictly within the lateral bands
(D) Transverse continuation of annulations across the field

2009

200. In evaluating nematode reproductive capacity, the term "syngamy" describes:
(A) The fusion of male and female gametes to form a zygote
(B) Development of an unfertilized egg into a male
(C) The functional development of both sperm and eggs in a single gonad
(D) Continuous vegetative reproduction

2010

201. Which term accurately describes a hermaphroditic nematode where sperm is produced first and stored, followed by oocyte production in the same gonad?
(A) Protogynous
(B) Parthenogenetic
(C) Dioecious
(D) Protandrous

2025

202. The most common mode of reproduction in the highly successful Meloidogyne incognita is:
(A) Obligate amphimixis
(B) Obligate mitotic parthenogenesis
(C) Facultative meiotic parthenogenesis
(D) Protandrous hermaphroditism

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2022

203. Which feature is highly characteristic of mitotic parthenogenesis in nematodes?
(A) Clonal reproduction resulting in offspring genetically identical to the mother
(B) Heavy reliance on males for triggering egg development
(C) Recombination of genetic material leading to highly diverse offspring
(D) The requirement of an extreme environmental trigger to initiate reproduction

2015

204. "Meiotic parthenogenesis" implies that:
(A) Meiosis is completely bypassed during oocyte formation
(B) Sperm strictly trigger development without contributing genetic material (pseudogamy)
(C) Oocytes undergo meiosis and diploidy is restored
(D) Only haploid males are produced

2001

205. Match the nematode reproductive strategy in List I with its definition in List II.
List I: (Reproductive Strategy)
P. Amphimixis
Q. Parthenogenesis
R. Hermaphroditism
S. Pseudogamy
List II: (Definition)
1. Reproduction without male fertilization
2. Standard sexual reproduction involving union of sperm and egg
3. Sperm penetration stimulates oocyte development but male DNA degrades
4. An individual produces both functional sperm and eggs
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-2, S-1

2008

206. Which internal structural element is primarily responsible for establishing and maintaining the typical cylindrical shape of the nematode body?
(A) Intracellular microtubules in the hypodermis
(B) The constant contraction of the longitudinal muscles
(C) Fluid pressure against the robust, layered cuticle
(D) The rigid, sclerotized esophageal structures

2001

207. A characteristic morphological feature of the genus Hemicycliophora is:
(A) The lack of any functional stylet
(B) An extraordinarily long, curved stylet and an extra cuticular sheath
(C) A strictly lemon-shaped mature female
(D) An asymmetric vulva located at the extreme anterior end

2019

208. The genus Hirschmanniella is economically most significant as a pest of:
(A) Deep-rooted orchard trees
(B) Greenhouse tomatoes
(C) Arid-climate cotton
(D) Flooded rice paddies

2013

209. Which feeding category accurately characterizes Hirschmanniella species (the rice root nematode)?
(A) Migratory endoparasite
(B) Sedentary endoparasite
(C) Ectoparasitic virus vector
(D) Semi-endoparasite forming cysts

2012

210. Which nematode genus is known as the "sting nematode" and represents one of the most highly destructive ectoparasites in sandy soils?
(A) Dolichodorus
(B) Hoplolaimus
(C) Belonolaimus
(D) Xiphinema

NODIA

2011

211. What distinctive feature of the head region aids in identifying Belonolaimus?
(A) Head region divided into four distinct lobes
(B) A perfectly continuous, smooth head profile lacking any lip sectors
(C) A cephalic region bearing large lateral horn-like projections
(D) A head totally enveloped by an extended body sheath

2023

212. The term "dimorphism" in nematode taxonomy almost exclusively refers to:
(A) Variation between geographically isolated populations
(B) Significant morphological differences between males and females of the same species
(C) The presence of two distinct stylet forms within a single individual during development
(D) The ability to feed on two entirely different

plant hosts

2004

213. A male nematode lacks an anal pore and instead possesses a structure serving both the digestive and reproductive systems. This is termed the:
(A) Rectum
(B) Cloaca
(C) Gubernaculum
(D) Bursa

2021

214. The structure called a "titillum" is occasionally associated with which male copulatory organ?
(A) The bursa
(B) The spicule
(C) The capitulum
(D) The gubernaculum

2007

215. Which of the following best describes the "capitulum" found in some male nematodes?
(A) A sensory papilla on the tail tip
(B) The muscular sheath surrounding the testis
(C) An extension of the lateral alae
(D) The flared, proximal head-like base of the spicule

2021

216. In defining nematode phylogeny, which feature heavily supports the position of Dorylaimida near the base of the modern Enoplea?
(A) Bottle-shaped esophagus and sensory arrangements
(B) Their lack of functional amphids
(C) Their obligate use of an ecdysone hormone for moulting
(D) Their universally unsegmented cuticle

2016

217. When applying molecular taxonomy, high ITS sequence similarity (e.g., $> 99\%$) combined with significant morphological divergence typically suggests:
(A) The organisms belong to entirely different phyla
(B) An error in PCR amplification
(C) The organisms have completely different chromosome numbers
(D) Recent speciation or high morphological plasticity

2015

218. Nematode DNA barcoding heavily utilizes the mitochondrial genome because it:
(A) Evolves extremely slowly, preventing intraspecific variation
(B) Lacks introns and features a relatively fast mutation rate
(C) Is perfectly conserved across all metazoan life
(D) Encodes the actual structural proteins of the cuticle

2011

219. The concept of a "superspecies" or species complex in nematology (e.g., the Meloidogyne incognita group) reflects:
(A) Closely related species that are morphologically cryptic
(B) A group of highly distinct, unrelated genera causing similar symptoms
(C) A single species capable of parasitizing all known plant groups
(D) A taxonomically obsolete term for any large nematode

2001

220. Select the correct sequence of fundamental operations in the formal description of a new nematode species.
(A) Manuscript publication → Extraction & Observation → DNA Sequencing → Designation of Type Specimens
(B) Extraction & Observation → DNA Sequencing → Designation of Type Specimens → Manuscript Publication
(C) DNA Sequencing → Manuscript Publication → Extraction & Observation → Designation of Type Specimens
(D) Designation of Type Specimens → Manuscript Publication → DNA Sequencing → Extraction & Observation

2014

221. Which specific component of the International Code of Zoological Nomenclature regulates the naming of families and subfamilies in nematology?
(A) The Principle of Binomial Nomenclature
(B) The Principle of Synonymy
(C) The Law of First Revision
(D) The Principle of Coordination

2006

222. Under the Principle of Coordination in the ICZN, establishing a new nominal family-group name automatically establishes:
(A) All valid species within that family
(B) The immediate priority over all higher phylum names

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(C) The corresponding coordinate nominal taxa with same author
(D) A mandate for comprehensive molecular barcoding

2023

223. The "Law of Priority" strictly applies to names published after which foundational date in zoological nomenclature?
(A) 1 January 1758
(B) 1 January 1855
(C) 1 January 1900
(D) 1 January 1950

2010

224. Which condition renders a proposed nematode name a "nomen dubium"?
(A) It is perfectly described with molecular data but no holotype
(B) It is a name that has been legally replaced by a junior synonym
(C) It is a name given to a species that was later found to be a plant
(D) The description is inadequate and the type is lost

2018

225. A "nomen nudum" in nematological taxonomy is a name that:
(A) Has been published without an accompanying description, definition, or indication to make it available
(B) Was published in a non-academic newspaper
(C) Was published anonymously
(D) Is actively used to describe an extinct nematode

2017

226. What evolutionary advantage is commonly attributed to the formation of the dauer larval stage?
(A) It drastically increases the immediate reproductive output
(B) It allows the nematode to switch to an autotrophic lifestyle
(C) It bridges temporal gaps in food availability and barriers
(D) It actively digests the host plant from the inside out

2001

227. In the life cycle of entomopathogenic nematodes (e.g., Steinernema), the infective juvenile (IJ) is structurally analogous to:
(A) The developmentally arrested dauer stage (J3)
(B) The adult reproductive female
(C) The first-stage juvenile (J1)
(D) The completely non-motile egg stage

2011

228. Which physiological adaptation heavily characterizes the infective juvenile (dauer) stage of insect-parasitic nematodes?
(A) Immediate maturation of the gonads
(B) Extreme swelling to store massive amounts of fat
(C) The shedding of the amphids
(D) Retention of the J2 cuticle as an environmental sheath

2010

229. The term "exsheathment" primarily refers to:
(A) A nematode emerging from the eggshell
(B) The shedding of a retained cuticular sheath in response to cues
(C) The process of dissolving the host plant cell wall
(D) The male forcefully piercing the female vulva

2010

230. Arrange the following molecular techniques in order of their typical historical development and application in nematode taxonomy.
1. Whole Genome Sequencing (WGS)
2. Protein Electrophoresis (Allozymes)
3. Polymerase Chain Reaction (PCR) based RFLP
4. Direct DNA Sequencing of the ITS region

(A) 2 - 3 - 4 - 1
(B) 2 - 4 - 3 - 1
(C) 3 - 2 - 4 - 1
(D) 4 - 3 - 2 - 1

2017

231. What is the fundamental principle differentiating PCR-RFLP from direct sequencing in species identification?
(A) RFLP sequences every single nucleotide, while direct sequencing only looks at restriction sites
(B) RFLP strictly utilizes RNA, whereas sequencing utilizes DNA
(C) RFLP requires living nematodes, whereas sequencing can use dead specimens
(D) RFLP uses enzyme patterns; sequencing reads exact code

2015

232. Which specialized morphological trait strongly aids in diagnosing species of the genus Macroposthonia (a ring nematode)?

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(A) Retrorse annules and an open vulva lacking lateral flaps
(B) The presence of a massive cuticular sheath
(C) The complete absence of annulations
(D) A highly elongated, filiform tail

2014

233. The genus Helicotylenchus is most commonly referred to by which common name?
(A) Lance nematode
(B) Spiral nematode
(C) Dagger nematode
(D) Lesion nematode

2017

234. In evaluating the "De Man" formula, if a nematode population exhibits a high degree of variation in the c ratio, it heavily implies significant morphological variability in which structure?
(A) The esophageal length
(B) The tail length
(C) The total body width
(D) The position of the vulva

2007

235. The "b-value" (De Man's index b) is highly sensitive to which of the following artifacts during slide preparation?
(A) Contraction of the esophageal region during fixation
(B) The bursting of the tail tip
(C) The uneven flattening of the mid-body
(D) The extrusion of the spicules

2007

236. What distinguishes a strictly factual application of Alpha taxonomy from Beta taxonomy in nematology?
(A) Alpha conducts strictly molecular tests; Beta conducts morphological measurements
(B) Alpha studies ecological interactions; Beta studies reproductive cycles
(C) Alpha names species; Beta arranges species into genera
(D) Alpha relies on living samples; Beta uses exclusively fossilized specimens

2005

237. The fundamental difference between holomyarian, meromyarian, and polymyarian muscle arrangements lies strictly in:
(A) The chemical composition of the actin filaments
(B) The type of nervous tissue innervating them
(C) Their specific location within the esophageal bulb
(D) Number and arrangement of muscle cells per quadrant

2025

238. In a polymyarian muscle arrangement, what is visually prominent when viewing a cross-section of the nematode?
(A) Only two massive muscle cells per quadrant
(B) A complete absence of any discrete cellular membranes between muscle fibers
(C) Numerous muscle cells extending into the body cavity
(D) The strict presence of circular muscle bands cutting across the longitudinal fibers

2018

239. The pharynx of most Secernentea is divided into three primary functional regions. Which region acts as the primary "pump" to draw in food?
(A) The procorpus
(B) The median bulb (metacorpus), when heavily muscularized
(C) The isthmus
(D) The stoma

2004

240. Which statement is generally factual regarding the feeding of Pratylenchus species?
(A) They form permanent feeding tubes and become strictly sedentary
(B) They feed exclusively on external root hairs without penetrating the root
(C) They rely strictly on symbiotic bacteria to pre-digest plant tissue
(D) Cortical migration causing extensive necrotic lesions

2012

241. Which of the following defines the Biological Species Concept in nematology?
(A) Interbreeding natural populations reproductively isolated
(B) Species strictly delineated by distinct molecular barcodes
(C) The identification of unique structural morphotypes
(D) The classification based solely on ecological niche utilization

2006

242. Why is the biological species concept extremely difficult to consistently apply in agricultural nematology?
(A) Because all nematodes look exactly alike
(B) Because many species reproduce via obligate

NODIA

parthenogenesis
(C) Because male nematodes are entirely extinct
(D) Because cross-breeding experiments with soil nematodes are strictly forbidden

2011

243. When a species is defined purely by its ecological role and host preference, which species concept is broadly being applied?
(A) The Ecological Species Concept
(B) The Biological Species Concept
(C) The Morphological Species Concept
(D) The Phylogenetic Species Concept

2014

244. A major advantage of the Phylogenetic Species Concept using molecular data in nematology is:
(A) It requires the cross-breeding of live populations
(B) It strictly relies on the visual observation of type specimens
(C) It completely negates the need for any formal nomenclature rules
(D) It differentiates cryptic species and parthenogenetic groups

2018

245. In molecular taxonomy, what is typically the first required step after extracting a single nematode for DNA analysis?
(A) Direct restriction enzyme digestion of the whole body
(B) PCR amplification of a specific target gene region
(C) Protein crystallization
(D) Gas chromatography of cuticular lipids

2002

246. Which structural component prevents the nematode from expanding dramatically radially when internal hydrostatic pressure increases?
(A) The rigid internal true coelom
(B) The heavily calcified median bulb
(C) Helical collagen fibers of the cuticle
(D) The continuous contraction of the circular musculature

2004

247. The term "anastomosis" in the context of the nematode lateral field refers to:
(A) The complete fusion of the male and female
(B) The internal connection between the intestine and the excretory system
(C) The connection of the amphid to the main nerve ring
(D) Fusing or branching of longitudinal cuticular incisures

2006

248. The cephalic sensory organs of a typical ancestral nematode consist of an inner and outer circle. What is the standard configuration?
(A) 6 inner labial papillae, 6 outer labial papillae, and 4 cephalic papillae
(B) 4 inner labial papillae, 8 outer labial papillae, and 4 cephalic papillae
(C) strictly 12 identical papillae in a single ring
(D) 2 massive papillae strictly corresponding to the amphids

2007

249. Which of the following correctly pairs a sensory organ with its primary sensory modality in nematodes?
(A) Phasmids - strictly photoreception
(B) Hemizonid - primarily thermoreception
(C) Deirids - strictly auditory reception
(D) Amphids - primarily chemoreception

2023

250. The "cardiac glands" or "cardia" are located immediately:
(A) Anterior to the nerve ring
(B) At the junction of the basal esophageal bulb and the intestine
(C) Within the tail terminus
(D) Surrounding the vulva

2012

251. Which best describes the function of the esophago-intestinal valve?
(A) Barrier preventing regurgitation of intestinal contents
(B) It is the primary site of respiratory gas exchange
(C) It forcefully injects powerful toxins into the host plant
(D) It actively sorts unfertilized eggs from fertilized ones

2005

252. The term "stichosome" is applied to an esophagus that:
(A) Is entirely non-functional and strictly vestigial
(B) Possesses three massive muscular bulbs arranged in sequence
(C) Consists of a capillary tube surrounded by gland cells
(D) Is deeply heavily sclerotized and functions as a secondary stylet

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2004

253. Which prominent nematode group, although largely animal parasitic (e.g., Trichinella), is classically characterized by possessing a stichosome esophagus?
(A) Tylenchida
(B) Enoplida
(C) Rhabditida
(D) Trichinellida

2007

254. When distinguishing between male and female nematodes, the presence of a "cloaca" is structurally exclusive to:
(A) Females, combining the reproductive and excretory tracts
(B) Both males and females universally
(C) Males, combining the digestive (hindgut) and reproductive tracts
(D) The specialized infective J2 stage

2011

255. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the options provided.
Assertion (A): Radopholus similis represents a significant threat to global banana production.
Reason (R): It causes severe mechanical damage and necrosis in the root cortex, leading to a condition known as "toppling disease" due to massive root structural failure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

256. Which symptom complex is strictly diagnostic of an advanced Meloidogyne infection in susceptible host crops?
(A) Discrete, localized necrotic black lesions on the main taproot
(B) Profuse proliferation of hairy roots specifically at the soil surface
(C) The immediate wilting and death of the plant within 24 hours of exposure
(D) Structural swelling of roots forming irregular galls

2011

257. What is a key structural distinction between the galls caused by Meloidogyne and the nodules formed by Rhizobium bacteria on legumes?
(A) Galls are structural root swelling; nodules are lateral appendages
(B) Nematode galls are highly organized appendages easily snapped off the root, while bacterial nodules are structurally integral to the root axis
(C) Nematode galls are strictly green and photosynthetic, whereas nodules are always white
(D) Nematode galls never contain any multinucleate cells

2015

258. The "citrus nematode" (Tylenchulus semipenetrans) establishes a specialized feeding site known as:
(A) A massive multinucleate giant cell
(B) A highly fused syncytium extending into the vascular cylinder
(C) modified, metabolically active cortical "nurse cells"
(D) A completely necrotic, liquefied cavity

2017

259. During nematode embryogenesis, the "gastrulation" phase is primarily characterized by:
(A) Inward migration of cell lineages to form the gut tube
(B) The immediate shedding of the eggshell
(C) The rapid, uncontrolled multiplication of strictly epidermal cells
(D) The formation of the rigid external cuticle

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2001

260. The "J1" (first stage juvenile) nematode is typically defined by which characteristic?
(A) It is the stage actively penetrating deep root tissues in all plant-parasitic species
(B) It represents the fully matured, reproductively active state
(C) It strictly features a fully functional set of spicules
(D) It is the initial form prior to the first moult

2019

261. Nematode longevity and survival in extreme environments can frequently involve a profound metabolic suspension termed:
(A) Diapause
(B) Cryptobiosis or anhydrobiosis
(C) Senescence
(D) Ecdysis

2002

262. Which structural molecule is heavily synthesized and utilized by nematodes like Aphelenchoides

and Ditylenchus during severe anhydrobiosis to protect cellular membranes?
(A) Cellulose
(B) Chitin
(C) Trehalose
(D) Keratin

2025

263. The term "nematode wool" historically refers to:
(A) The dense fungal mycelium heavily trapping nematodes
(B) The highly setose (hairy) cuticle of marine nematodes
(C) The fibrous root system heavily proliferated by Heterodera infection
(D) Desiccated aggregates of thousands of Ditylenchus juveniles

2013

264. In the classification framework of Order Tylenchida, which morphological feature is absolutely universal?
(A) The possession of a hollow stomatostylet
(B) A distinct, heavily calcified bursa
(C) A highly enlarged, fully external pair of amphids
(D) A strictly didelphic female reproductive tract

2003

265. Match the morphological descriptor in List I with the most appropriate nematode structure in List II.
List I: (Descriptor)
P. Leptoderan
Q. Holomyarian
R. Monodelphic
S. Tylenchoid
List II: (Structure/Arrangement)
1. Somatic muscle arrangement consisting of a continuous layer
2. A male bursa not extending to the absolute tail tip
3. An esophagus characterized by a procorpus, median bulb, isthmus, and basal bulb
4. A female reproductive system possessing a single functional ovary
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-4, R-1, S-3

2019

266. A male nematode possessing a pair of distinct spicules but totally lacking a gubernaculum indicates:
(A) A severe genetic mutation ensuring sterility
(B) That the presence/absence of a gubernaculum is a naturally highly variable taxonomic trait among different nematode groups
(C) The nematode is actually a strictly hermaphroditic female
(D) The specimen is currently undergoing a moult

2014

267. The presence of a prominent "phasmid" on the tail of a juvenile nematode immediately places it broadly within the traditional class:
(A) Secernentea
(B) Adenophorea
(C) Enoplea
(D) Dorylaimea

2010

268. Which feature strongly differentiates a standard Heterodera cyst from the dead body of a Pratylenchus female?
(A) The Pratylenchus female transforms into a tanned, resilient cuticular sac protecting eggs, whereas the Heterodera female simply decomposes
(B) Heterodera lacks a cuticle entirely
(C) Heterodera bodies form rigid cysts retaining eggs
(D) Pratylenchus strictly retains a heavily visible bursa

2016

269. The specific cuticular structure in Heterodera cysts that breaks down to allow hatched juveniles to exit is known as the:
(A) Vulval slit
(B) Excretory pore
(C) Amphidial aperture
(D) Fenestra (vulval or perineal)

2007

270. What is a "bullae" in the strict context of cyst nematode morphology?
(A) A heavily expanded median bulb
(B) The specialized spicule guide in the male
(C) Sclerotized knob structures near the vulval cone
(D) A fluid-filled sac replacing the internal intestine

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2018

271. Which diagnostic structure is located precisely beneath the vulval bridge in the cysts of some Heterodera species?
(A) The stichosome
(B) The underbridge
(C) The basal bulb
(D) The capitulum

2008

272. In defining the morphology of the genus Aphelenchoides, the median esophageal bulb is characteristically:
(A) Entirely absent
(B) Highly reduced and lacking any valve
(C) Located distinctly posterior to the nerve ring
(D) Exceptionally massive and squarely occupying the body

2004

273. How does the arrangement of esophageal glands generally differ between Tylenchida and Aphelenchida?
(A) Gland orifice location relative to stylet base or bulb
(B) In Tylenchida, the dorsal gland empties strictly into the median bulb; in Aphelenchida, it empties near the base of the stylet
(C) Aphelenchida lack esophageal glands entirely
(D) Tylenchida have five distinct glands, whereas Aphelenchida have only one

2007

274. Which specialized form of reproduction is frequently utilized by Aphelenchoides besseyi (causal agent of rice white tip disease)?
(A) Obligate syngamy
(B) Binary fission
(C) Facultative meiotic parthenogenesis
(D) Polyembryony

2005

275. Consider the following statements regarding nematode feeding and ecology:
I. Trichodorids primarily cause damage by directly penetrating the vascular cylinder.
II. Xiphinema species represent some of the largest root-parasitic nematodes.
III. Many dorylaimids are free-living omnivores or predators rather than strict plant parasites.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

2005

276. The disease broadly known as "red ring of coconut" is directly caused by:
(A) Bursaphelenchus cocophilus
(B) Radopholus similis
(C) Aphelenchoides ritzemabosi
(D) Heterodera avenae

2017

277. The primary vector for the red ring nematode (Bursaphelenchus cocophilus) is:
(A) A fungal zoospore
(B) The South American palm weevil (Rhynchophorus palmarum)
(C) Migratory birds
(D) Contaminated irrigation water

2007

278. Which distinctive symptom gives "red ring disease" its name?
(A) The massive production of bright red galls on the superficial roots
(B) The sudden appearance of bright red cuticular rings on the mature female nematodes
(C) A brick-red to brownish band visible in the trunk cross-section
(D) The secretion of a red, gummy exudate from the leaf fronds

NODIA

2013

279. The Order Dorylaimida is morphologically separated from Tylenchida heavily by the presence of a(n):
(A) Exceptionally massive, multi-valved median bulb
(B) Heavily overlapping glandular stichosome
(C) Cuticle entirely lacking any structural cross-linking
(D) Two-part, bottle-shaped esophagus lacking a valvular bulb

2021

280. A crucial evolutionary adaptation distinguishing typical Xiphinema feeding from typical Pratylenchus feeding is:
(A) Xiphinema ectoparasitism with an elongated odontostylet
(B) Xiphinema strictly enters the root cortex fully and migrates destructively
(C) Xiphinema strictly feeds on fungal hyphae, not plant roots
(D) Xiphinema relies exclusively on capturing passing bacteria

2025

281. The term "nepovirus" strictly stands for:
(A) Nematode-eating predatory virus
(B) Nematode-transmitted polyhedral virus
(C) Non-encapsidated parasitic virus
(D) New plant virus

2012

282. "Tobravirus" strictly stands for:
(A) Tobacco rattle virus
(B) Tomato bushy root virus
(C) Tobamovirus-related aphid virus
(D) Nematode-transmitted tubular virus (specifically Tobacco rattle)

2010

283. Which statement accurately represents the virus transmission mechanism in Xiphinema?
(A) Particles bind to cuticular linings and are flushed out during feeding
(B) The virus particles massively replicate within the nematode intestine before being injected
(C) The virus particles are strictly retained within the nematode egg and passed to the next generation
(D) The nematode passively carries the virus externally on its body surface

2009

284. Does a virus-transmitting nematode retain the virus following a successful moult?
(A) Yes, the virus is strictly integrated into the nematode genome
(B) No, because the virus resides exclusively deep within the mid-gut, which is not shed
(C) No, because the cuticular lining where the virus binds is shed
(D) No, because the moult triggers a massive immune response that destroys all viruses

2023

285. Consider the following statements concerning Longidorus morphology:
I. It possesses a highly elongated, strictly hollow odontostylet.
II. It features prominent, massive flanged knobs at the base of the odontophore.
III. The guiding ring is situated near the anterior (distal) tip of the stylet.
IV. It universally transmits tobraviruses.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) I, II, and III
(D) I and IV

2019

286. What is a "peg" in the taxonomic terminology of the nematode tail?
(A) The hardened spicule of the male
(B) The internal connection of the phasmids
(C) A sharp, distinct cuticular projection strictly at the tail terminus
(D) The thickened cuticular region directly surrounding the anus

2016

287. Which feature is traditionally diagnostic for differentiating the genus Rotylenchus from Helicotylenchus?
(A) Rotylenchus has a heavily elongated stylet exceeding 150 µm
(B) Rotylenchus possesses highly distinct, overlapping esophageal glands that overlap the intestine primarily dorsally
(C) Rotylenchus lacks any cuticular annulations
(D) Rotylenchus females are strictly didelphic

2002

288. Which specific sensory structure heavily aids in the immediate taxonomic diagnosis of Dorylaimid nematodes from Tylenchid nematodes?
(A) Dorylaimids lack amphids completely
(B) Tylenchids possess massively enlarged, highly visible phasmids near the head
(C) Dorylaimids universally possess three massive distinct eyespots
(D) Dorylaimids have large, pouch-like amphids; Tylenchids have pore-like ones

2022

289. The specialized excretory structure found uniquely in members of the family Tylenchulidae (e.g., Tylenchulus semipenetrans) heavily features:
(A) A highly posteriorly displaced excretory pore located far down the body near the equatorial region
(B) A massive, heavily cuticularized prominent pore located precisely at the lip region
(C) The complete absence of any visible excretory pore
(D) Multiple distinct pores scattered laterally

2019

290. The concept of a "neotype" heavily ensures which of the following in modern nematology?
(A) That every newly discovered variant is given a totally new name
(B) The immediate invalidation of all older morphological literature
(C) Taxonomic stability when original type

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materials are lost
(D) That molecular data permanently overrides morphological data

2015

291. What characterizes the "V-value" within De Man's morphological indices?
(A) It denotes the distance from the anterior end strictly to the vulva, definitively expressed as a percentage of the total body length
(B) It represents the strictly vertical dimension of the mid-body
(C) It calculates the total volume of the pseudocoelom
(D) It measures the velocity of standard juvenile movement

2024

292. In the context of the root-knot nematode life cycle, what highly specific environmental cue primarily initiates the hatching of the J2 from the egg in many species?
(A) Strictly a sudden, massive drop in soil temperature
(B) Immediate exposure to direct sunlight
(C) High concentrations of carbon monoxide in the soil
(D) Moisture, temperature, and root exudates from a host

2023

293. The structural origin of the nematode epicuticle is:
(A) Exclusively secreted by symbiotic cuticular bacteria
(B) Strictly a heavily hardened exudate originating directly from the hypodermis
(C) Synthesized completely independently by specialized environmental cells
(D) Derived strictly from modified plant cell walls

2002

294. The specific phenomenon of "endotokia matricida" (often observed in Rhabditis or aging cyst nematodes) refers to:
(A) The rapid ingestion of the mother by external predators
(B) The heavily directed killing of competing males by the female
(C) Intra-uterine hatching where juveniles consume the maternal body
(D) The strictly asexual division of the adult female into multiple clones

2025

295. Consider the following statements concerning the nematode reproductive system:
I. The "rachis" is a central non-cellular core found strictly in telogonic ovaries, around which developing germ cells are typically arranged.
II. The "spermatheca" is a strictly male organ utilized for storing mature sperm prior to copulation.
III. The "vagina" serves as the heavily muscularized terminal portion of the female genital tract connecting the uterus to the external vulva.
IV. "Hologonic" gonads produce germ cells strictly along their entire length.
V. Parthenogenesis entirely prevents the formation of any cuticular structures.
Which of the above statement(s) is/are correct?
(A) I, III, and IV
(B) I, II, and III
(C) II, IV, and V
(D) III, IV, and V

2012

296. A primary structural feature distinguishing a "telogonic" gonad from a "hologonic" gonad is:
(A) Telogonic proliferation is confined to a distal tip zone
(B) Telogonic gonads are found strictly in males; hologonic gonads strictly in females
(C) Telogonic gonads lack a distinct rachis completely
(D) Hologonic gonads are heavily heavily cuticularized

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2005

297. The term "odontophore" strictly refers to:
(A) The solid, cutting tip of the dorylaimid feeding apparatus
(B) Posterior stoma extension supporting the odontostylet
(C) The primary nerve cord innervating the stylet muscles
(D) The muscular basal bulb of the esophagus

2011

298. Which highly distinctive behavioral trait heavily aids in identifying members of the genus Criconemoides under a stereomicroscope?
(A) Rapid, highly erratic swimming in water droplets
(B) Sluggish earthworm-like contraction using cuticular annules
(C) The rapid, continuous flicking of the tail

terminus

(D) Instantaneous coiling into a tight spiral when illuminated

2009

299. In evaluating the diagnostic morphology of Globodera cysts, the absence of which specific structure definitively separates it from typical Heterodera cysts?

(A) The distinct, projecting vulval cone

(B) The external cyst wall

(C) The internal eggs

(D) The internal granular syncytium

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2018

300. The primary underlying mechanism that renders root-knot nematodes successfully polyphagous is:

(A) Their exclusive reliance on random physical mechanical wounding rather than highly specialized molecular interaction

(B) Their possession of an incredibly massive, heavily cuticularized stomatostylet capable of forcefully piercing any known biological material

(C) Secretion of effector proteins that manipulate host pathways

(D) Their ability to survive entirely as free-living soil saprophytes when no host is present

****

ANSWERS

1. (A) A pseudocoelom lacking a continuous mesodermal lining
Nematodes possess a pseudocoelom, which is a fluid-filled body cavity located between the endoderm-derived intestine and the mesoderm-derived body wall. Unlike a true coelom, this cavity lacks a continuous peritoneal lining derived from mesoderm. This structure serves as a hydrostatic skeleton, providing structural support and facilitating the transport of nutrients and metabolic waste throughout the unsegmented body.

2. (C) Locomotion using muscle contractions against fluid pressure
The hydrostatic skeleton functions by maintaining high internal fluid pressure within the pseudocoelom against the tough, elastic cuticle. This pressure allows the longitudinal muscles to work antagonistically, enabling the characteristic undulatory movement. This system is essential for locomotion and provides structural rigidity, allowing the nematode to navigate through soil pores or host tissues effectively without a bony internal framework.

3. (A) The presence of ectoderm, mesoderm, and endoderm germ layers
Triploblastic development in nematodes refers to the formation of three distinct primary germ layers during embryogenesis: the ectoderm, mesoderm, and endoderm. These layers give rise to all specialized tissues and organs. Specifically, the ectoderm forms the cuticle and nervous system, the mesoderm develops into the musculature, and the endoderm produces the epithelial lining of the entire digestive tract.

4. (D) They exhibit a highly developed continuous respiratory system
Nematodes lack a specialized respiratory system, such as lungs or gills, for gas exchange. Instead, they rely entirely on the diffusion of oxygen and carbon dioxide across their permeable cuticle and body wall. This physiological limitation typically necessitates a slender, vermiform body shape to maintain a high surface-area-to-volume ratio, ensuring efficient gas transport to internal tissues and essential organs.

5. (B) A muscular pharynx to pump food against internal pressure
High internal turgor pressure within the pseudocoelom creates a significant force that would normally prevent the ingestion of food. To overcome this resistance, nematodes have evolved a powerful muscular pharynx. This specialized organ acts as a suction pump, forcefully drawing food into the stoma and pushing it into the intestine against the substantial internal pressure of the body cavity.

6. (C) Absence of functional cilia or flagella in somatic cells
A defining morphological feature of Phylum Nematoda is the complete absence of functional cilia or flagella in any somatic cells. Even nematode sperm cells are amoeboid rather than flagellated. This distinguishes them from other pseudocoelomate groups, such as Rotifera, which possess a ciliated corona used for locomotion and feeding. This lack of cilia is consistent throughout all life stages.

7. (D) Periodic moulting of a cuticle mediated by ecdysteroids
The Ecdysozoa hypothesis groups nematodes with arthropods and other molting animals based on the periodic shedding of their non-living cuticle. This process, known as ecdysis, is regulated by ecdysteroid hormones. Growth occurs in discrete stages separated by these molting events, as the rigid outer cuticle must be replaced to allow the organism to increase in size and develop.

8. (A) Tardigrades possess lobopodal legs, whereas nematodes are unsegmented and legless
Tardigrades are characterized by the presence of four pairs of unjointed, lobopodal legs tipped with claws, whereas nematodes are strictly unsegmented, vermiform, and entirely lack appendages. While both groups belong to the Ecdysozoa and undergo molting, their body plans differ significantly in symmetry and locomotion. Tardigrades exhibit a segmented appearance, while nematodes maintain a smooth, continuous body wall.

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9. (B) Adult nematomorphs have a degenerate gut and no excretory system
Adult nematomorphs, or horsehair worms, are distinguished from nematodes by their degenerate digestive systems and the absence of a functional excretory system. While larval nematomorphs are parasitic, the adults are free-living in aquatic environments and do not feed, relying entirely on energy reserves. In contrast, most adult nematodes maintain a complete, functional digestive tract throughout their entire life cycle.

10. (B) Ecdysozoans defined by rDNA and moulting behaviors
Modern evolutionary biology places nematodes within the superphylum Ecdysozoa. This classification is supported by molecular data, particularly small subunit ribosomal DNA sequences, and the shared physiological trait of molting a three-layered cuticle. This placement separates them from the Lophotrochozoa and highlights their closer relationship to arthropods, reflecting a common ancestor that evolved the complex process of hormonal ecdysis.

11. (A) Independent loss of the coelom from a coelomate ancestor
Grouping Nematoda within Ecdysozoa suggests that the pseudocoelomate condition is a secondary simplification rather than a primitive state. This implies an independent loss of the true coelom from a coelomate ancestor shared with arthropods. This evolutionary transition highlights that structural complexity can be reduced over time, and the pseudocoelom serves as a highly functional alternative for these vermiform organisms.

12. (C) The universal presence of a closed circulatory system
Ecdysozoans are characterized by a layered cuticle and the process of molting, but they do not universally possess a closed circulatory system. Many members, like nematodes, lack a circulatory system entirely, relying on the pseudocoelomic fluid for transport. Others, like arthropods, possess an open circulatory system. A closed circulatory system is not a defining synapomorphy for this diverse group.

13. (D) Nematomorpha
The clade Nematoida is a well-supported monophyletic group consisting of the Phylum Nematoda and its sister group, the Phylum Nematomorpha. These two phyla share several fundamental characteristics, including a lack of circular muscles in the body wall, similar sperm morphology, and a collagenous cuticle. This sister-group relationship distinguishes them from other Ecdysozoan lineages such as Panarthropoda or Scalidophora.

14. (C) Nathan Augustus Cobb
Nathan Augustus Cobb established nematology as a distinct scientific discipline in the United States. He developed specialized equipment, extraction methods like the sifting and gravity technique, and standardized terminology for describing nematode anatomy. His extensive contributions to taxonomy and his focus on the economic impact of plant-parasitic species earned him the title of the father of American nematology.

15. (C) A is true but R is false.
B.G. Chitwood's classification divided nematodes based on the presence of phasmids, making the first statement true. However, phasmids are caudal sensory organs, not cephalic ones, making the second statement false. While phasmids are characteristic of Secernentea, which includes many parasites, their anatomical location is strictly in the posterior region, serving as chemoreceptors for environmental and chemical signals.

16. (D) B. G. Chitwood
Benjamin Goodwin Chitwood, along with his wife May Belle Chitwood, authored the seminal work "An Introduction to Nematology." This comprehensive textbook established a foundational framework for nematode morphology, physiology, and taxonomy. It remains a primary reference for researchers, providing detailed illustrations and descriptions that stabilized the scientific study of nematodes during the mid-twentieth century and influenced generations of scientists.

17. (A) H. C. Bastian
Henry Charlton Bastian published the "Monograph on the Anguillulidae" in 1865, which is considered a landmark in early nematology. This work provided the first detailed descriptions of numerous free-living and plant-parasitic nematodes, many of which were collected from soil and freshwater. Bastian's

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meticulous observations laid the groundwork for systematic taxonomy before the field was formally recognized as a discipline.

18. (C) J. G. de Man
Johannes Govertus de Man was a Dutch zoologist who revolutionized nematode taxonomy by introducing standardized morphometric indices. These ratios, known as the de Man indices, compare body length to width, esophageal length, and tail length. These measurements provide a consistent framework for species descriptions and remain fundamental tools for taxonomists to differentiate species based on proportional body dimensions and characteristics.

19. (A) Publishing "Plant Parasitic Nematodes and the Diseases they Cause"
Tom Goodey was a prominent British nematologist whose work focused on the practical and taxonomic aspects of plant-parasitic nematodes. His book, "Plant Parasitic Nematodes and the Diseases they Cause," became a standard text for understanding nematode-plant interactions and diagnostics. Goodey's contributions were instrumental in advancing the agricultural application of nematology, helping to identify and manage major crop-damaging species globally.

20. (D) H. C. Bastian - Discovery of the first nematode genome sequence
Henry Charlton Bastian is celebrated for his 1865 monograph on free-living nematodes, but he did not discover the first nematode genome sequence. Genomic sequencing is a modern development, with Caenorhabditis elegans being the first multicellular organism to have its genome sequenced in 1998. The other pairings correctly reflect the historical contributions of Cobb, de Man, and Chitwood to taxonomy.

21. (B) Needham's observation in 1743
The first scientific observation of a plant-parasitic nematode occurred in 1743 when Turbevill Needham discovered "vibrios" inside galled wheat seeds. Upon adding water, the dormant juveniles resumed movement, demonstrating the phenomenon of anhydrobiosis. This discovery marked the beginning of plant nematology, identifying Anguina tritici as the cause of wheat gall disease long before the microscopic nature of pathogens was understood.

22. (C) Documenting features and establishing type specimens
Alpha taxonomy involves the fundamental descriptive process of identifying, naming, and classifying new species. This includes documenting unique morphological features, taking precise measurements, and designating type specimens for deposition in museum collections. This stage is critical because it provides the formal scientific name and the standard reference material upon which all subsequent ecological or phylogenetic research is based.

23. (D) Intraspecific variation and speciation mechanisms
Gamma taxonomy moves beyond simple description and generic grouping to study the evolutionary processes within species. It focuses on intraspecific variation, population genetics, and the mechanisms of speciation. By examining how nematode populations adapt to different hosts or environments, gamma taxonomy provides insights into the evolutionary history and biological complexity of these organisms, often utilizing molecular and biogeographical data.

24. (A) Species are diagnosed based on consistent, observable structural differences
The Morphological Species Concept defines a species as a group of individuals that are structurally distinct from other such groups. In nematology, this involves comparing physical traits like stylet length, esophageal structure, and tail shape. While modern molecular methods are increasing, most described nematode species are still recognized based on these observable and measurable phenotypic characteristics as seen under microscopy.

25. (A) P-4, Q-3, R-2, S-1
The International Code of Zoological Nomenclature defines specific terms to ensure taxonomic stability. A synonym refers to different names for the same taxon, while a homonym occurs when identical names are used for different taxa. A topotype is a specimen from the original type locality, and a basionym is the original name on which a new combination is based.

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26. (B) The oldest available, validly published name for a taxon is its accepted name
The Principle of Priority is a fundamental rule of the ICZN designed to maintain stability in nomenclature. It dictates that the oldest validly published name for a taxon, starting from Linnaeus's 1758 work, must be recognized as the correct name. This prevents confusion when multiple names are proposed for the same species, ensuring that the first researcher's work is honored.

27. (A) The original author's name is placed in parentheses, optionally followed by the new author's name
According to ICZN rules, when a species is moved to a new genus, the name of the original author is enclosed in parentheses. This indicates that the current generic placement is different from the one originally proposed. For example, if a researcher transfers a species to a more appropriate genus, the original authorship remains cited to maintain the historical taxonomic record.

28. (C) Two different names are explicitly based on the same type specimen
An objective synonym occurs when two or more names are applied to the same taxon and are based on the exact same type specimen. This is a matter of nomenclature rather than taxonomic opinion. Because the names are linked to the same physical standard, one must be rejected in favor of the other based on the Principle of Priority.

29. (D) Meloidogyne incognita sp. nov.
Binomial nomenclature requires the genus name to be capitalized and the species epithet to be in lowercase, with both typically italicized or underlined. The abbreviation "sp. nov." indicates a new species description. This standardized format ensures that scientific names are universally recognizable and consistent across all biological literature, facilitating clear communication among researchers regarding specific nematode taxa and their classifications.

30. (C) Taxonomists differing in their opinion on whether two distinct type specimens represent the same species
A subjective synonym is created when a taxonomist decides that two different species, described from different type specimens, are actually the same. This is a matter of taxonomic judgment rather than a nomenclatural rule. If subsequent researchers agree that the specimens belong to a single species, the older name takes priority, and the junior name becomes a subjective synonym.

31. (B) It is considered a nomen nudum and is unavailable
Under the ICZN, a name published without a formal description, definition, or designated type specimen is considered a nomen nudum. Such names are unavailable for use in formal taxonomy and have no standing in the Principle of Priority. This rule ensures that every scientific name is tied to specific morphological or molecular data, preventing the use of meaningless or undocumented names.

32. (D) The single physical specimen designated to represent the species
A holotype is the single physical specimen designated by the original author at the time of the species description to serve as the definitive standard for the taxon. It is the name-bearing type that anchors the scientific name. In nematology, the holotype is usually a permanently mounted slide of a single individual, preserved in a recognized museum or institutional collection.

33. (A) Paratypes are extra specimens with a holotype; syntypes are used when no holotype is designated
Paratypes are additional specimens from the same series used in the original description when a holotype is designated. They show the range of variation within the species. Syntypes are used when an author describes a species based on a series of specimens without designating a single holotype. In such cases, all specimens in the series have equal standing as name-bearing types.

34. (C) Original type material is lost or destroyed and a standard is needed
A neotype is designated only when the original type material (holotype, lectotype, or syntypes) is confirmed to be lost or destroyed. The designation must be necessary to solve a complex taxonomic problem or to clarify the application of a name. A neotype must come from a locality as close as possible to the original type locality to ensure taxonomic consistency.

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35. (A) I and II
In taxonomic typification, an allotype is a paratype of the opposite sex to the holotype, and a lectotype is a single specimen selected from a syntype series to become the unique name-bearing type. Both statements I and II are correct. However, a topotype is simply a specimen from the type locality and holds no official name-bearing status under the ICZN.

36. (D) Any remaining syntype specimen after a lectotype has been formally designated
When a researcher selects one specimen from an original syntype series to serve as the lectotype, the remaining specimens in that series automatically become paralectotypes. These specimens are still historically significant as they were part of the author's original concept of the species, but they no longer hold the status of the primary name-bearing type for that taxon.

37. (B) Total body length divided by maximum body width
The de Man index a is a standard morphometric ratio calculated by dividing the total body length of the nematode by its maximum body width. This value provides a numerical representation of the specimen's slenderness. A higher a value indicates a very thin, elongated nematode, while a lower value reflects a more robust or swollen body shape, aiding in species differentiation.

38. (C) The ratio of tail length to the anal body width
The morphometric index c' is the ratio of the tail length to the anal body width. This value is particularly useful in nematode taxonomy because it standardizes tail shape across individuals of different sizes. It helps differentiate species with long, slender tails from those with short, blunt tails, providing a more precise diagnostic tool than absolute tail length alone.

39. (D) The distance to the vulva as a percentage of total body length
The $V\%$ index is a critical taxonomic character representing the distance from the anterior end to the vulva, expressed as a percentage of the total body length. This value indicates the relative position of the female reproductive opening. $V\%$ is remarkably consistent within species and is used extensively in identification keys to separate genera and species with different reproductive anatomies.

40. (A) Allometric growth causes ratios to vary between juveniles and adults
The primary limitation of de Man's indices is allometric growth, where different parts of the nematode body grow at different rates. For example, the esophagus often grows more slowly than the total body length, causing the b index to change as the nematode matures. Consequently, these ratios are most reliable when comparing individuals at the same developmental stage, particularly adults.

41. (B) 20
The de Man index c is calculated by dividing the total body length by the tail length. In this specific case, 1000 micrometers divided by 50 micrometers equals 20. This ratio is a standard metric used to describe the relative length of the tail, providing a consistent way for taxonomists to compare tail proportions regardless of the absolute size of the specimen.

42. (B) As percentages of body length to specific structural landmarks
Cobb's formula represents nematode morphometrics by expressing the distance to major anatomical landmarks as percentages of the total body length. These landmarks typically include the base of the stoma, the nerve ring, the excretory pore, the base of the esophagus, the vulva or mid-body, and the anus. This provides a standardized linear "map" of the nematode's internal organization.

43. (A) Odontostylet length and $V\%$
Within the genus Xiphinema, or dagger nematodes, the length of the odontostylet and the position of the vulva ($V\%$) are among the most stable and diagnostically significant characters. These measurements are less affected by environmental factors compared to total body length. Precise determination of these two features allows taxonomists to reliably separate many of the numerous closely related species.

44. (C) The presence or absence of phasmids (caudal sensory organs)
B.G. Chitwood's bipartite classification system was fundamentally based on the presence or absence of phasmids, which are paired sensory organs located in the tail region. Nematodes possessing phasmids were placed in the Class Secernentea (meaning "secretors"), while those lacking them were assigned to the Class

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Adenophorea (meaning "gland bearers"). This division also reflected differences in the excretory system.

45. (A) Both A and R are true and R is the correct explanation of A.
Modern molecular phylogenetics has shown that the traditional Class Adenophorea is paraphyletic. SSU rDNA data indicates that the Class Secernentea is actually a specialized clade that evolved from within an Adenophorean lineage. This finding has necessitated a reclassification, as a truly monophyletic group must include all descendants of a common ancestor, leading to the adoption of the Enoplea and Chromadorea classes.

46. (C) Chromadorea and Enoplea
Current molecular taxonomy, primarily based on small subunit (18S) rDNA sequences, divides the Phylum Nematoda into two main classes: Chromadorea and Enoplea. Chromadorea contains the former Secernenteans and some Adenophoreans, characterized by specific molecular signatures. Enoplea contains the remaining Adenophorean groups. This classification better reflects the evolutionary lineages of nematodes compared to older systems based purely on the presence of phasmids.

47. (B) Dorylaimida
The Order Dorylaimida, characterized by its specialized odontostylet and bottle-shaped esophagus, was historically placed in the Class Adenophorea. In modern molecular phylogeny, it remains a central and diverse group within the Class Enoplea. Dorylaimids are found in terrestrial and freshwater habitats and include significant plant parasites as well as numerous free-living predatory and omnivorous species that are ecologically important.

48. (D) Clade XII (Tylenchomorpha / Chromadorea)
The plant-parasitic order Tylenchida is situated within the Class Chromadorea, specifically in Clade XII according to the phylogenetic framework established by Blaxter and colleagues. This clade, also known as Tylenchomorpha, includes the majority of economically important plant-parasitic nematodes. Their placement here reflects a common evolutionary origin shared with rhabditid nematodes, supported by both molecular data and specific morphological traits in their digestive systems.

49. (A) Conserved regions mixed with variable regions for evolutionary comparison
The SSU (18S) rRNA gene is ideal for deep phylogenetic reconstruction because it contains highly conserved regions that change very slowly over time, allowing for comparisons between distant lineages. These are interspersed with variable regions that provide resolution for more closely related groups. This mosaic structure allows scientists to build a stable evolutionary tree spanning the entire Phylum Nematoda and beyond.

50. (D) III only
Statement III is correct as modern phylogenetics places Rhabditida and Tylenchida in the Class Chromadorea. Statement I is incorrect because Secernentea, not Adenophorea, typically possess a tubular excretory system with lateral canals. Statement II is incorrect because Secernentea possess both amphids and phasmids, although their amphids are often small and pore-like compared to those of many Enopleans.

51. (A) Cytochrome c oxidase subunit I (COI)
The mitochondrial COI gene is the internationally recognized DNA barcode for the animal kingdom, including nematodes. It provides a standardized molecular marker for species-level identification because it evolves rapidly enough to show differences between closely related species but is conserved enough within a species. This allows researchers to match unknown specimens against a global database of known sequences for accurate diagnosis.

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52. (D) ITS evolves faster, providing resolution for species diagnostics
The Internal Transcribed Spacer (ITS) regions of ribosomal DNA evolve more rapidly than the 18S or 28S coding genes. This higher mutation rate results in significant sequence variation between closely related species, such as different types of Meloidogyne. Consequently, the ITS region provides the necessary genetic resolution to distinguish species that may appear morphologically identical or share highly conserved 18S sequences.

53. (B) Restriction Fragment Length Polymorphism (PCR-RFLP)
PCR-RFLP involves amplifying a specific DNA region, such as the ITS or COI, and then digesting the resulting amplicons with restriction

enzymes. These enzymes cut the DNA at specific sequences, creating fragments of different sizes. When separated by electrophoresis, these fragments produce a characteristic banding pattern, or "fingerprint," that can be used to identify nematode species based on their unique genetic sequences.

54. (C) To selectively amplify DNA from a target species in a mixed sample
Species-specific primers are designed to match DNA sequences found only in a particular nematode species. During PCR, these primers will only bind to and amplify the DNA of the target organism, even if the sample contains DNA from multiple other species. This allows for the rapid and precise detection of specific pests directly from soil or plant tissue extracts without manual sorting.

55. (B) I, III, and V
Statement I is correct as the D2-D3 regions are standard for identification. Statement III is correct because multiplex PCR can detect multiple targets at once. Statement V is correct as qPCR provides both ID and quantification. Statement II is false because COI is used, and statement IV is false because mitochondrial genomes are much smaller than nuclear ones in nematodes.

56. (A) High substitution rates often cause standard universal primers to fail
While the COI gene is a standard barcode, its high rate of nucleotide substitution in nematodes can lead to "primer mismatch." Universal primers designed for other animals often fail to bind to the diverse mitochondrial sequences of nematodes. This necessitates the development of group-specific or degenerate primers, making the molecular identification of some nematode lineages more technically challenging than in other animal groups.

57. (B) Structural proteins such as collagens and specialized cuticlins
The nematode cuticle is a complex, non-cellular extracellular matrix composed primarily of structural proteins. Collagens are the most abundant component, providing flexibility and strength. Another group of insoluble proteins, known as cuticlins, adds further structural integrity. Unlike the chitin-rich exoskeleton of arthropods, the nematode cuticle relies on cross-linked proteins to withstand high internal hydrostatic pressure and provide protection from the environment.

58. (B) Epicuticle
The epicuticle is the thin, outermost layer of the nematode cuticle and serves as the primary interface between the organism and its environment. It is composed of multiple sub-layers, including a lipid-rich layer that provides selective permeability. This crucial barrier regulates the movement of water, ions, and chemicals into the body, protecting the nematode from desiccation, toxins, and host immune responses.

59. (A) Extensive disulfide cross-linking of collagen trimers
The strength and elasticity of the nematode cuticle are derived from the molecular organization of collagen. Collagen molecules form trimers that are stabilized and connected by extensive disulfide cross-linking. This biochemical network creates a robust but flexible sheath that can resist the high internal turgor pressure of the pseudocoelom while allowing the body to flex and bend during undulatory locomotion and feeding.

60. (C) Inner layers are enzymatically dissolved and the outer is shed
During moulting, or ecdysis, the nematode secretes enzymes that partially dissolve the inner layers of the old cuticle. This process creates space for the synthesis of a new cuticle by the hypodermis. Once the new cuticle is formed, the remnants of the old outer cuticle are shed. This allows the nematode to grow and transition through its four juvenile stages into adulthood.

61. (D) The hypodermis (epidermis)
The hypodermis, also known as the epidermis, is the living tissue layer immediately beneath the cuticle. It is responsible for the synthesis and secretion of all cuticular components. During each moult, the hypodermal cells become metabolically active, producing the proteins and lipids required to form the new cuticle layers before the old one is shed. The hypodermis also forms the longitudinal chords.

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62. (C) Spirally arranged, intersecting collagenous fibers
In many larger nematodes, the mesocuticle is a complex layer containing highly organized, spirally arranged collagen fibers. These fibers often occur in two or three layers that intersect at specific angles. This geodesic-like arrangement provides exceptional structural integrity and allows for changes in body length and width during movement, preventing the body from kinking or rupturing under high internal pressure.

63. (B) Annulations
Annulations are transverse grooves or striations on the surface of the nematode cuticle that create a superficially segmented appearance. These markings are not true segments but rather structural modifications that enhance body flexibility. The size and spacing of these annules vary among taxa and are used in taxonomy. In some groups, like ring nematodes, these annulations are extremely prominent and deep.

64. (D) To permit expansion during feeding or body flexure
The lateral fields, or incisures, are longitudinal markings on the cuticle that often overlie the lateral hypodermal chords. These structures are thought to provide flexibility, allowing the cuticle to expand or contract during feeding, egg production, or body bending. By acting as "pleats," they prevent the cuticle from overstretching, helping the nematode maintain its structural integrity while undergoing physiological changes.

65. (A) Areolation
Areolation occurs when the transverse cuticular annulations extend across the longitudinal lines of the lateral field. This creates a pattern of small, rectangular or block-like segments within the lateral bands. The presence and extent of areolation, particularly in the cervical or caudal regions, are important diagnostic characters used by taxonomists to distinguish between closely related species and genera.

66. (C) Punctations
Punctations are minute, distinct dot-like structures or depressions found on the surface of the cuticle. They are often arranged in precise longitudinal or transverse rows. These features are actually structural elements that extend into the deeper layers of the cuticle. Punctations are common in many free-living and marine nematodes and serve as useful taxonomic markers for identification and classification at various levels.

67. (A) Alae
Alae are wing-like expansions of the cuticle that run longitudinally along the body. They are most commonly found in the lateral regions and can be classified as cervical alae (near the head), caudal alae (near the tail, often forming the male bursa), or longitudinal alae. These structures are involved in locomotion and sensory functions, and their morphology is a key taxonomic character.

68. (D) Patterns of perineal punctations and vulval fenestrae
Identification of Heterodera cysts relies heavily on the morphology of the vulval cone region. This includes the arrangement of fenestrae, which are thin, transparent areas of the cuticle, and the presence of punctations or bullae. These patterns are unique to different species and remain visible after the female has died and transformed into a cyst, making them essential for diagnosing these important agricultural pests.

69. (B) Muscle cells form a continuous layer not interrupted by hypodermal chords
In a holomyarian muscle arrangement, the longitudinal somatic muscle cells form a continuous, uninterrupted layer around the inner circumference of the body wall. Unlike other arrangements, they are not separated into distinct fields by the dorsal, ventral, or lateral hypodermal chords. This pattern is relatively rare among nematodes and is typically found in some small, primitive, or specialized groups.

70. (C) Numerous muscle cells projecting into the pseudocoelom
A polymyarian muscle arrangement is characterized by the presence of numerous longitudinal muscle cells within each of the four quadrants formed by the hypodermal chords. These muscle cells are usually narrow and tall, with their non-contractile portions projecting significantly into the pseudocoelom. This arrangement is common in larger nematodes, such as Ascaris, providing the power needed for movement in large-bodied organisms.

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71. (D) 2 to 5 cells
Meromyarian nematodes possess a limited and fixed number of longitudinal muscle cells. In this arrangement, typically only two to five muscle cells are found in each of the four quadrants between the hypodermal chords. This pattern is common in many small nematodes, including most plant-parasitic and many free-living species. The small number of cells is sufficient for the undulatory locomotion required in their micro-environments.

72. (A) The non-contractile muscle arm or innervation process
Nematodes have a unique neuromuscular organization where the muscle cells extend processes to the nervous system, rather than nerves extending to the muscles. Each somatic muscle cell has a non-contractile "muscle arm" or innervation process that reaches out to contact the dorsal or ventral nerve cords. This allows the nervous system to coordinate the contractions required for the nematode's characteristic undulatory movement.

73. (B) Alternating dorsal/ventral contractions for undulatory waves
Nematodes move by generating undulatory waves of contraction that pass along the body. This is achieved through the alternating contraction and relaxation of the dorsal and ventral longitudinal muscles. Since they lack circular muscles, they cannot undergo peristalsis. The high internal fluid pressure acts as an antagonist to these muscle contractions, allowing the body to snap back and propel the nematode forward.

74. (B) The pharyngeal (esophageal) musculature
The pharyngeal or esophageal musculature is structurally and functionally independent of the somatic longitudinal muscles. While the somatic muscles are responsible for body movement, the pharyngeal muscles are specialized for feeding. They are often arranged radially within the esophagus, allowing it to act as a powerful pump to ingest food against the high internal pressure of the pseudocoelom.

75. (A) Both A and R are true and R is the correct explanation of A.
Nematodes are restricted to dorso-ventral undulatory movement because their body wall only contains longitudinal muscles. They lack the circular muscle fibers found in many other worms like annelids. Without circular muscles to act antagonistically to the longitudinal ones, nematodes cannot perform the lengthening and shortening required for peristaltic crawling. Instead, they must push against soil particles or surfaces using undulatory waves.

76. (C) Laterally in the cephalic (head) region
Amphids are complex, paired sensory organs located laterally in the cephalic or head region of nematodes. They consist of an external aperture, a fluid-filled fovea, and a bundle of sensory neurons. Amphids are the primary chemoreceptors, allowing the nematode to detect host signals, pheromones, and environmental gradients. Their shape and size vary greatly and are fundamental characters used in nematode classification.

77. (D) Chemoreception for host and pheromone location
The primary function of amphids is chemoreception. These organs contain specialized sensory neurons that detect chemicals in the environment. For plant-parasitic nematodes, amphids are crucial for locating host roots by detecting root exudates. They also play a role in sensing pheromones for mating and monitoring environmental conditions. This chemo-sensory capability is vital for the survival and reproductive success of both free-living and parasitic nematodes.

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78. (C) Phasmids
Phasmids are paired sensory organs located in the lateral fields of the tail region, primarily found in the Class Secernentea. Structurally, they are similar to small amphids, consisting of a gland and sensory neurons opening to the exterior via a pore. Phasmids are thought to function as chemoreceptors or mechanoreceptors, helping the nematode perceive its posterior environment and potentially playing a role in mating.

79. (B) In the lateral fields near the level of the nerve ring
Deirids are small, paired sensory papillae located laterally, typically near the level of the nerve ring or the excretory pore. They are considered mechanoreceptors that help the nematode sense contact with the surrounding soil or host tissue. Deirids are often associated with the lateral fields of the cuticle and provide important

positional information that assists the nematode in navigating its environment.

80. (B) 2 - 3 - 1 - 4
In a typical plant-parasitic nematode, the structures are arranged from anterior to posterior starting with the stylet used for penetration. Following the stylet is the median bulb (metacorpus), which acts as a pump. The nerve ring then encircles the esophagus, usually posterior to the median bulb. Finally, the basal bulb (esophageal glands) is located at the junction with the intestine.

81. (A) A nerve commissure located ventrally near the excretory pore
The hemizonid is a distinct, lenticular structure found in the ventral hypodermal chord, usually situated just anterior to the excretory pore. It represents a large nerve commissure that connects the ventral nerve cord with other parts of the nervous system. The hemizonid is a common feature in many nematodes and is often used as a landmark for orientation during morphological examinations under the microscope.

82. (C) A hollow spear formed from fused, cuticularized stoma walls
A stomatostylet is a hollow, needle-like feeding structure characteristic of the Order Tylenchida. It is derived from the sclerotized walls of the stoma. The stomatostylet consists of three parts: the anterior cone, the cylindrical shaft, and the basal knobs. The basal knobs serve as attachment points for the protractor muscles, which allow the nematode to protrude the stylet to puncture plant cell walls.

83. (A) The anterior esophageal wall (sub-cuticular origin)
The odontostylet is the specialized feeding spear found in the Order Dorylaimida. Unlike the stomatostylet, it originates from the anterior part of the esophagus and is formed within a specialized cell during development. It is essentially a large, modified tooth that is hollow and used for piercing cells. During moulting, a replacement odontostylet is often visible in the esophageal wall of the juvenile stages.

84. (D) A solid curved tooth with a guide tube in Trichodoridae
An onchiostylet, found in stubby-root nematodes of the Family Trichodoridae, is a solid, ventrally curved tooth. Unlike the hollow stomatostylets or odontostylets, it does not have a central lumen for fluid transport. Instead, it is used to rapidly peck and slash at plant cells. The nematode then ingests the cell contents that leak out. It is often associated with a complex “guide tube” within the stoma.

85. (A) P-3, Q-4, R-1, S-2
Nematode groups are often identified by their feeding apparatus. Stomatostylets are found in Tylenchids like Heterodera. Odontostylets are characteristic of Dorylaimids like Xiphinema. Onchiostylets are unique to Trichodorids like Trichodorus. Free-living rhabditid nematodes like Caenorhabditis lack a stylet and possess a simple, tubular rhabditoid stoma adapted for ingesting bacteria from the surrounding environment or decomposing organic matter.

86. (C) The basal knobs
The basal knobs of a stomatostylet are sclerotized structures located at the posterior end of the spear. Their primary function is to provide a robust attachment site for the protractor muscles. When these muscles contract, they pull the knobs forward, causing the stylet to protrude through the oral opening. This mechanical action is necessary for the nematode to puncture plant cell walls and initiate feeding.

87. (D) A metacorpus with valve plates, an isthmus, and a basal bulb
A tylenchoid esophagus is the classic arrangement found in many plant-parasitic nematodes. It consists of a narrow procorpus, followed by a muscular median bulb (metacorpus) containing valvular plates. Posterior to the median bulb is a slender isthmus, which is surrounded by the nerve ring. Finally, there is a glandular basal bulb that contains the esophageal glands and connects to the intestine via the cardia.

88. (A) The dorsal gland opens into the median bulb anterior to the valve
The aphelenchoid esophagus is distinguished from the tylenchoid type primarily by the location of the dorsal esophageal gland orifice. In aphelenchoid nematodes, the dorsal gland empties into the lumen of the median bulb, just anterior to the crescentic valve. In contrast, in tylenchoid nematodes, the dorsal gland opens into the esophagus much further forward, near the base of the stylet knobs.

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89. (B) A slender anterior part and an expanded posterior cylinder
A dorylaimoid esophagus is characterized by a "bottle-shaped" appearance. It consists of a slender, muscular anterior section and a broader, heavily muscularized posterior cylinder. This posterior section contains the esophageal glands and acts as the primary pump for drawing in food. dorylaimoids lack the distinct median valvular bulb and isthmus found in tylenchoid nematodes, reflecting a different evolutionary strategy for food ingestion.

90. (B) Rhabditoid
The rhabditoid esophagus is typical of free-living bacterial feeders. It features a broad corpus (divided into procorpus and metacorpus), a narrow isthmus, and a prominent basal bulb. This basal bulb contains a specialized "butterfly" or "rhabditoid" valve that functions to grind and pump bacteria into the intestine. This structure is highly efficient for ingesting small particulate food from the soil or decomposing matter.

91. (A) Extra-corporeal digestion and host cell modification
Esophageal glands in plant-parasitic nematodes secrete a variety of proteins and enzymes, collectively known as effectors. These secretions are injected into host plant cells via the stylet. They serve several critical roles: softening cell walls to facilitate penetration, initiating extra-corporeal digestion, and manipulating host cell metabolism to induce specialized feeding sites, such as giant cells or syncytia, which are essential for the nematode's survival.

92. (C) A tubular system with H-shaped or inverted lateral canals
The secretory-excretory (S-E) system in the Class Secernentea is a complex tubular network. It typically consists of a ventral excretory pore and a duct that connects to two longitudinal lateral canals running within the hypodermal chords. This "H-shaped" or "inverted U-shaped" system allows the nematode to collect waste and regulate fluids from across its entire body, maintaining osmotic balance within the pseudocoelom.

93. (D) A single ventral rennette cell lacking lateral canals
In most Adenophorean nematodes, the excretory system is relatively simple compared to Secernenteans. It usually consists of a single large glandular cell, called the rennette cell, located ventrally in the anterior body. This cell opens directly to the exterior through a ventral excretory pore. These nematodes generally lack the extensive network of lateral longitudinal canals found in the more derived Secernentean tubular excretory systems.

94. (C) Osmoregulation and secretion of specialized glycoproteins
The primary function of the nematode S-E system is osmoregulation, helping the organism maintain internal fluid balance and pressure. It also plays a role in the secretion of glycoproteins and enzymes. For example, in some species, the S-E system secretes a gelatinous matrix to protect eggs. It may also produce enzymes involved in the moulting process, facilitating the breakdown and shedding of the old cuticle.

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95. (B) The presence of a single ovary/genital tract
A monodelphic female nematode possesses only one functional ovary and its associated reproductive tract. This is a common morphological arrangement and is often combined with other terms to describe the direction of the tract. For instance, a monodelphic prodelphic nematode has a single ovary extending anteriorly from the vulva. This anatomical simplification is used as a diagnostic character in nematode taxonomy and classification.

96. (D) Didelphic amphidelphic
A didelphic amphidelphic reproductive system consists of two ovaries and their corresponding genital tracts that extend in opposite directions from a centrally located vulva. One tract extends anteriorly, while the other extends posteriorly. This symmetrical arrangement is common in many nematode groups and allows for the simultaneous production and storage of a larger number of eggs compared to monodelphic systems.

97. (A) Spermatheca
The spermatheca is a specialized, often expanded region of the female reproductive tract where sperm is stored after copulation. In many species, fertilization occurs as the mature oocytes pass through the spermatheca. The presence and shape of the spermatheca are important taxonomic features. In hermaphroditic species, the spermatheca stores sperm produced

by the individual's own gonad prior to oocyte maturation.

98. (C) The ovary and genital tract extend anteriorly from the vulva
In a prodelphic reproductive system, the ovary and the rest of the genital tract are situated anterior to the vulva. If there is only one such tract, the nematode is described as monodelphic prodelphic. This orientation is a significant morphological trait used to categorize and identify various nematode genera, particularly within the Order Tylenchida, where the position of the vulva and ovary orientation are key characters.

99. (A) Testes emptying into a common cloaca with the digestive tract
In male nematodes, the reproductive system is structurally integrated with the posterior end of the digestive tract. The vas deferens joins the rectum to form a common chamber called the cloaca, which opens to the exterior via the cloacal pore. This shared exit serves for both the elimination of waste and the transfer of sperm. Males also possess specialized copulatory structures, such as spicules, associated with the cloaca.

100. (B) Ovary → Oviduct → Spermatheca → Uterus → Vagina
The female reproductive tract is organized to facilitate oocyte maturation, fertilization, and egg deposition. The process begins in the ovary, where oocytes are produced. They then travel through the oviduct to the spermatheca for fertilization. The fertilized eggs move into the uterus, where eggshell formation is completed. Finally, the eggs are expelled through the vagina and the external vulva into the surrounding environment.

101. (B) The presence of a single testis
A monorchic male nematode possesses only one functional testis. This is a common condition in many nematode species, particularly within the Class Chromadorea. The testis is typically a tubular organ where sperm are produced and matured before being stored in the vas deferens. In contrast, diorchic males have two testes. Testis number is a stable morphological character used in the classification of male nematodes.

102. (C) To penetrate the female vulva and hold it open for sperm transfer
Spicules are paired, sclerotized, and often curved structures found in the cloaca of male nematodes. Their primary function during copulation is to penetrate the female vulva and serve as a conduit or brace to hold the vagina open. This allows the non-flagellated, amoeboid sperm to be transferred from the male cloaca into the female reproductive tract. Spicule shape and size are highly species-specific.

103. (D) A sclerotized trough structure that guides the spicules
The gubernaculum is a sclerotized, plate-like or trough-shaped structure located in the dorsal wall of the male cloaca. Its primary function is to guide the spicules as they are protruded and retracted during mating. By providing a stable track, the gubernaculum ensures that the spicules are correctly oriented to enter the female vulva. The morphology of the gubernaculum is an important diagnostic character in male taxonomy.

104. (A) A peloderan bursa encloses the tail; leptoderan leaves it free
The bursa, or caudal alae, is a lateral cuticular expansion at the posterior end of male nematodes used for gripping the female. A peloderan bursa is characterized by extending all the way to and enclosing the tip of the tail. In contrast, a leptoderan bursa is shorter and does not reach the tail tip, leaving it free. This distinction is a key taxonomic feature used to identify male nematodes.

105. (A) Both A and R are true and R is the correct explanation of A.
Nematode sperm are unique among animals because they lack flagella and are completely acontractile in their immature state. Upon activation, they develop pseudopods and move via amoeboid crawling. This movement is powered by the polymerization of Major Sperm Protein (MSP) rather than actin. This specialized motility allows the sperm to navigate through the female reproductive tract to reach and fertilize the oocytes in the spermatheca.

106. (B) Modified bilateral or strictly determinate cleavage
Nematode embryos typically exhibit determinate cleavage, where the developmental fate of each

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early blastomere is fixed very early. The cleavage pattern is not strictly spiral or radial but is often described as a modified bilateral or rotational pattern. This highly regulated process ensures that each cell lineage gives rise to specific tissues and organs, a characteristic that led to nematodes being models for developmental biology.

107. (A) The P cell lineage (specifically P4)
During early embryogenesis, the nematode embryo divides into somatic and germline lineages. The germ line is derived exclusively from the P cell lineage. Specifically, the P4 blastomere is the primordial germ cell that will eventually give rise to all the gametes (sperm and eggs) in the adult nematode. This early segregation of the germ line is a hallmark of the highly determinate development seen in nematodes.

108. (C) Four
Following hatching, nematodes typically progress through four juvenile stages (designated J1 to J4) before reaching sexual maturity as adults. Each stage is separated by a moult, where the old cuticle is shed and replaced by a new, larger one. This four-stage developmental pattern is remarkably consistent across most nematode phyla, although the location and timing of the first moult can vary among different species.

109. (D) In ovum, before the juvenile hatches from the egg
In many economically important plant-parasitic nematodes, such as Meloidogyne (root-knot) and Heterodera (cyst) species, the first moult occurs while the nematode is still inside the eggshell. Therefore, it is the second-stage juvenile (J2) that actually hatches from the egg. This J2 stage is the mobile, infective stage that must locate and penetrate a suitable host plant root to continue its development and life cycle.

110. (A) 3 - 2 - 1 - 4
The life cycle of Meloidogyne incognita begins with the first moult (J1 to J2) occurring inside the egg. The infective J2 then hatches and penetrates a host root. Once inside, the nematode establishes a permanent feeding site and becomes sedentary. After several more moults, the mature female begins laying eggs into an external gelatinous matrix, completing the cycle and ensuring the infestation of the surrounding soil.

111. (B) Cessation of cell division leading to a fixed cell number
Eutely is a biological phenomenon where an adult organism has a fixed and constant number of somatic cells. In nematodes, most cell divisions cease once the juvenile reaches the adult stage, except within the germ line. This means that growth in adults occurs through an increase in cell size (hypertrophy) rather than cell number (hyperplasia). Eutely contributes to the highly predictable and consistent anatomy of many nematode species.

112. (D) Overcrowding, pheromones, and food scarcity
The dauer juvenile is a specialized, alternative third-stage larval form (J3) that nematodes enter when environmental conditions are unfavorable for growth and reproduction. High population density (sensed through pheromones), lack of food, and extreme temperatures trigger this developmental switch. The dauer stage is adapted for survival and dispersal, allowing the nematode to persist for long periods until conditions improve and it can resume normal development.

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113. (A) J3
In the model organism Caenorhabditis elegans, the transition to the dauer stage occurs at the end of the second juvenile stage (J2). Therefore, the dauer larva itself is a specialized, developmentally arrested form of the third juvenile stage (J3). Once favorable conditions return, the dauer larva undergoes a specialized moult to become a fourth-stage juvenile (J4), eventually reaching adulthood and resuming its reproductive life cycle.

114. (C) A thickened cuticle and closure of the oral opening
A dauer juvenile possesses several morphological adaptations for long-term survival. Its cuticle is significantly thickened and reinforced to resist desiccation and chemical stress. Additionally, the oral opening is closed, and the pharynx is modified into a non-feeding state, allowing the nematode to conserve energy. These features, combined with an accumulation of storage lipids, enable the dauer stage to survive for months without external nutrients.

115. (A) I and II
Statements I and II are correct as nematodes exhibit determinate cleavage, and the E blastomere specifically gives rise to the intestinal tissues. Statement III is incorrect because in most plant-parasitic species, the J1 stage does not feed; it typically moults into the J2 stage while still inside the egg or shortly after hatching, with the J2 being the primary feeding and infective stage.

116. (D) Heterodera
The genus Heterodera is characterized by the formation of cysts. After the sedentary female finishes laying some eggs, her body wall undergoes a chemical tanning process, turning into a hard, brown, protective sac. This cyst retains most of the eggs internally, protecting them from environmental hazards and predators for several years. This survival mechanism is a defining feature of the cyst-forming nematodes in agriculture.

117. (B) The second-stage juvenile (J2)
In the life cycle of Meloidogyne species, the second-stage juvenile (J2) is the critical infective stage. After hatching from the egg in the soil, the J2 must locate a host root using chemical cues. Once a root is found, the J2 uses its stylet to penetrate the tissue, usually near the root tip, and migrates to establish a permanent feeding site, eventually becoming sedentary.

118. (C) External gelatinous matrix egg deposition instead of cyst retention
Adult Meloidogyne females are distinguished from Heterodera females by their method of egg deposition. Meloidogyne females remain soft-bodied and secrete a protective gelatinous matrix from their rectal glands, into which they lay their eggs outside their body. In contrast, Heterodera females transform into hard cysts that retain most of their eggs internally. This difference in reproductive strategy is a primary diagnostic character for these two major genera.

119. (D) Pratylenchus
Root-lesion nematodes belong to the genus Pratylenchus. They are migratory endoparasites that move through the root cortex, feeding on cells and causing extensive necrotic lesions. Unlike root-knot or cyst nematodes, they do not become sedentary or induce specialized feeding sites. Instead, their movement and feeding directly destroy root tissues, leading to reduced nutrient uptake and secondary infections by other soil-borne pathogens like fungi and bacteria.

120. (A) The number of lip annules and the shape of the tail terminus
Taxonomic identification of Pratylenchus species relies heavily on subtle morphological features. The number of cuticular annules in the lip region and the specific shape of the female tail terminus (e.g., rounded, truncate, or pointed) are primary diagnostic characters. Because these nematodes are migratory and lack complex sedentary structures, these stable cuticular details are essential for distinguishing between the numerous closely related species in this genus.

121. (D) Males possess a degenerate stylet and are non-feeding
Radopholus similis, the burrowing nematode, shows significant sexual dimorphism. Mature females are vermiform, possess a robust functional stylet, and are the primary agents of root damage. In contrast, the adult males have a much smaller, degenerate stylet and a poorly developed esophagus, rendering them unable to feed. Their primary biological role is fertilization, and they are typically much less common in host tissues than the parasitic females.

122. (B) Rotylenchulus
Rotylenchulus reniformis is known as the reniform nematode because the mature female adopts a characteristic kidney-like or "reniform" shape. This nematode is a semi-endoparasite; the anterior portion of the female's body is embedded in the root to feed, while the posterior portion swells and remains outside the root. This genus is an important pest of many tropical and subtropical crops, including cotton, pineapple, and various vegetables.

123. (A) Semi-endoparasitically with the posterior body outside
Mature females of Rotylenchulus reniformis exhibit a semi-endoparasitic feeding habit. The nematode's head and neck region penetrate deep into the root cortex to establish a feeding site, while the posterior part of the body remains outside the root surface. As the female matures and begins egg production, this external portion swells into the diagnostic kidney shape. The eggs are then laid into an external gelatinous matrix.

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124. (C) A gelatinous matrix incorporating soil particles
The citrus nematode, Tylenchulus semipenetrans, is a semi-endoparasite where the female's posterior body remains on the root surface. She secretes a gelatinous matrix that covers her body and the eggs she lays. This matrix often traps soil particles, giving the infected roots a "dirty" or gritty appearance. This protective coating helps safeguard the eggs from desiccation and natural enemies while they develop in the soil environment.

125. (D) Spiral body posture when relaxed and a short tail
Helicotylenchus, commonly known as spiral nematodes, are identified by their characteristic spiral or "C" shape when they are relaxed or heat-killed. They generally have a short, blunt tail and a robust stylet with distinct knobs. These nematodes are primarily ectoparasites or semi-endoparasites on a wide range of plants. Their spiral posture is a very consistent behavioral trait used by nematologists for rapid preliminary identification.

126. (C) Hoplolaimus
The genus Hoplolaimus comprises the lance nematodes. These are relatively large, robust nematodes characterized by a heavily sclerotized cephalic framework and a very strong stylet with massive, often tulip-shaped basal knobs. They are migratory endoparasites or semi-endoparasites that cause significant mechanical damage to root tissues. Their common name, "lance nematode," reflects their powerful feeding spear and the destructive nature of their feeding within host roots.

127. (B) Stylet with tulip-shaped knobs and overlapping glands
Hoplolaimus species are distinguished by their robust stomatostylet, which features characteristic "tulip-shaped" or three-lobed basal knobs. Additionally, their esophageal glands are well-developed and notably overlap the anterior end of the intestine. These morphological features, along with a heavily sclerotized head and large, prominent phasmids (scutella), are diagnostic for the genus. They are destructive parasites that feed on the roots of many important agricultural crops.

128. (D) Deep, retrorse annulations often with crenate margins
Ring nematodes of the Family Criconematidae are unique due to their extremely thick cuticle with deep, backward-projecting (retrorse) transverse annulations. These annules may have smooth, crenate, or even fringed margins depending on the genus and species. This specialized cuticle gives them a caterpillar-like appearance and provides protection and traction as they move slowly through the soil, making them morphologically distinct from most other nematode groups.

129. (A) Sluggish contractions using the annulated cuticle for traction
Ring nematodes move through the soil with a slow, telescopic contraction and expansion of their body, which is quite different from the rapid undulatory movement of most nematodes. Their deep, retrorse cuticular annules act like the treads on a tire, providing the necessary traction against soil particles. This sluggish but powerful mode of locomotion is an adaptation to their specific ecological niche as ectoparasites in soil environments.

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130. (C) Foliar/leaf nematodes
The genus Aphelenchoides includes species commonly known as foliar or leaf nematodes. Unlike most plant-parasitic nematodes that attack roots, these species primarily infest the above-ground parts of plants, such as leaves, stems, and flower buds. They move in films of water on the plant surface and enter through stomata. Important species include Aphelenchoides ritzemabosi and A. besseyi, which cause significant damage to ornamental and food crops.

131. (A) Feeding on leaf mesophyll and many are also fungivorous
Many Aphelenchoides species exhibit a versatile feeding habit. While some are specialized parasites that feed on the mesophyll cells of plant leaves, many are also capable of feeding and reproducing on various fungi. This fungivorous ability allows them to survive in the soil or on decaying plant matter when a suitable host plant is not available. This ecological flexibility contributes to their persistence and spread in agricultural and natural environments.

132. (D) Aphelenchoides lacks a bursa, while Aphelenchus possesses one
Although Aphelenchoides and Aphelenchus both belong to the Order Aphelenchida and share similar esophageal structures, they can be distinguished by male reproductive characters. Male Aphelenchus species possess a distinct, albeit small, bursa (caudal alae) supported by ribs, which is used during mating. In contrast, males in the genus Aphelenchoides completely lack a bursa. This morphological difference is a primary diagnostic feature used to separate these two closely related genera.

133. (B) Bursaphelenchus
The pine wood nematode, Bursaphelenchus xylophilus, is the causal agent of pine wilt disease, which has devastated forests in Asia and parts of Europe. This nematode is unique because it is transmitted from tree to tree by bark beetles. Once inside a susceptible pine tree, the nematodes multiply rapidly in the resin canals, causing the tree to wilt and die within a single growing season, making it a major quarantine concern.

134. (C) Transportation by longhorn beetles (genus Monochamus)
Bursaphelenchus xylophilus has a highly specialized symbiotic relationship with longhorn beetles of the genus Monochamus. The nematodes utilize the beetles as vectors for dispersal. When a beetle emerges from an infested tree, it carries thousands of third-stage dispersal juveniles (J3) or specialized J4 dauer stages in its tracheal system. As the beetle feeds on or lays eggs in healthy pine trees, the nematodes exit the beetle and infect the new host.

135. (A) Both A and R are true and R is the correct explanation of A.
The pine wood nematode, Bursaphelenchus xylophilus, relies on Monochamus beetles for its dispersal. As the beetle matures within an infested tree, the nematodes aggregate and moult into a specialized fourth-stage dispersal juvenile (J4). These juveniles are adapted to enter the beetle's respiratory system (tracheae). When the adult beetle flies to a new tree, the nematodes are transported safely, ensuring the successful colonization of new host trees by the parasite.

136. (A) A characteristic vulval flap covering the genital pore
A prominent diagnostic feature in many Bursaphelenchus species, including the pine wood nematode, is the presence of a vulval flap in the adult female. This cuticular structure extends from the anterior margin of the vulva and covers the opening. The size and shape of this flap, along with the tail morphology and the presence of a small mucro, are important characters used by taxonomists to identify and distinguish different species within this genus.

137. (B) Dorylaimida
The Order Dorylaimida is defined by its unique two-part esophagus and a specialized feeding spear called an odontostylet. The esophagus consists of a slender anterior portion and an expanded, muscular posterior cylinder. The odontostylet is a hollow tooth derived from the esophageal wall. This group includes significant plant-parasitic genera like Xiphinema and Longidorus, as well as many free-living soil and freshwater nematodes that play vital roles in nutrient cycling and ecology.

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138. (B) Xiphinema
Dagger nematodes belong to the genus Xiphinema. They are relatively large, ectoparasitic nematodes that feed on root tips using a very long odontostylet. Beyond direct feeding damage, Xiphinema species are economically critical because they are the primary vectors for Nepoviruses, such as Grapevine fanleaf virus. Their long-lived nature and deep-feeding habits make them difficult to manage in perennial crops like grapes, fruit trees, and various ornamental plants.

139. (A) Xiphinema has flanged extensions; Longidorus lacks true flanges
Although both Xiphinema and Longidorus possess long odontostylets, they can be distinguished by the base of the stylet extension (odontophore). In Xiphinema, the base of the odontophore has three prominent, sclerotized flanges that serve as muscle attachment points. Longidorus lacks these distinct flanges, and its odontophore base is relatively simple. This structural difference is a fundamental diagnostic feature used to separate these two important genera of virus-vectoring nematodes.

140. (A) Posterior in Xiphinema, and near the anterior tip in Longidorus
The position of the stylet guiding ring is a key diagnostic character. In Xiphinema, the guiding ring is located relatively far back on the odontostylet, usually near the junction with the odontophore. In contrast, in Longidorus, the guiding ring is situated much closer to the anterior end of the head. This difference in ring placement is easily visible under a light microscope and is a reliable way to distinguish between these two genera.

141. (D) Longidorus
Needle nematodes belong to the genus Longidorus. They are among the largest plant-parasitic nematodes, with some species reaching lengths of over 10 millimeters. They are migratory ectoparasites that use their exceptionally long, needle-like odontostylets to feed on the root tips of many plants, particularly trees and grasses. Their feeding causes the root tips to swell and stop growing, and some species are also vectors for economically important plant viruses.

142. (C) Trichodorus and Paratrichodorus
Stubby-root nematodes are primarily represented by the genera Trichodorus and Paratrichodorus. These nematodes are migratory ectoparasites that feed on root tips, causing them to become stunted, swollen, and "stubby" in appearance. This damage significantly impairs the plant's ability to take up water and nutrients. In addition to direct feeding damage, these genera are the only known vectors for Tobraviruses, which cause diseases such as tobacco rattle and corky ringspot.

143. (D) Triplonchida
Stubby-root nematodes, comprising the family Trichodoridae, are classified within the Order Triplonchida. This order is distinct from the Tylenchida and Dorylaimida. Triplonchids are characterized by their unique onchiostylet, which is a solid, curved feeding tooth. Their placement in this order reflects their specific evolutionary lineage and morphological characteristics, including their unique esophageal structure and the absence of certain sensory and reproductive features found in other nematode groups.

144. (D) A solid, curved, dorsally grooved onchiostylet
Trichodorus and Paratrichodorus species possess a unique feeding apparatus called an onchiostylet. Unlike the hollow stylets of other plant parasites, the onchiostylet is a solid, ventrally curved tooth with a longitudinal groove. It is used to rapidly puncture host cell walls. The nematode then forms a "feeding tube" made of hardened saliva to ingest the cell contents. This specialized mechanism is a defining characteristic of the stubby-root nematode family.

145. (A) P-2, Q-1, R-3, S-4
Different nematode genera are specific vectors for different plant viruses. Xiphinema species transmit Nepoviruses like Grapevine fanleaf virus, while Longidorus transmits Nepoviruses like Tomato black ring virus. In contrast, Trichodorus and Paratrichodorus are vectors for Tobraviruses. Trichodorus is associated with Tobacco rattle virus, and Paratrichodorus transmits Tobraviruses like Pea early-browning virus. These specific vector-virus relationships are critical for understanding and managing the spread of plant viral diseases.

146. (C) Puncturing outer root cells creating a tube of secretions
Stubby-root nematodes use their solid onchiostylet to rapidly peck at the surface of root cells. As they feed, they secrete a specialized saliva that hardens to form a "feeding tube" connecting the nematode's mouth to the punctured cell. This tube allows the nematode to efficiently suck up the cytoplasm and nutrients that leak out of the damaged cell. This unique feeding behavior causes the characteristic stunting and swelling of the root tips.

147. (A) Posterior cuticle swells on fixation in Paratrichodorus
A classic diagnostic feature used to separate Paratrichodorus from Trichodorus is the reaction of the cuticle to chemical fixation. In Paratrichodorus species, the cuticle typically swells and pulls away from the body, particularly in the posterior region, when the nematode is killed and preserved. This "swelling" effect is generally absent in Trichodorus. This simple morphological reaction is a reliable tool for taxonomists to distinguish between these two closely related genera of stubby-root nematodes.

148. (D) It contains prominent radial muscle fibers allowing it to function as a powerful pump
In the Order Dorylaimida, the expanded posterior portion of the esophagus is a highly muscularized

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cylinder. It contains prominent radial muscle fibers that allow it to act as a powerful suction pump. This structure is essential for drawing in food through the long, narrow odontostylet. The powerful pumping action of the dorylaimoid basal bulb is a defining physiological and morphological characteristic that supports the feeding requirements of these diverse terrestrial and aquatic nematodes.

149. (B) Replacement odontostylet formation in the anterior esophagus
In Dorylaimid nematodes, the odontostylet is replaced during each of the four juvenile moults. A new "replacement" odontostylet is synthesized within a specialized cell in the anterior esophageal wall before the old one is shed. This replacement stylet is often clearly visible in the esophagus of juvenile specimens under the microscope. Once the old cuticle and stylet are shed, the new odontostylet moves forward into its functional position in the stoma.

150. (C) Xiphinema
Dagger nematodes of the genus Xiphinema are well-known for inducing characteristic terminal galls on the roots of their host plants. As they feed ectoparasitically on the meristematic tissue at the root tip, their secretions trigger localized cell division (hyperplasia) and enlargement (hypertrophy). This results in the formation of swollen, hooked, or galled root tips. These galls provide a nutrient-rich environment for the nematode and are a diagnostic symptom of Xiphinema infestation.

151. (D) Ditylenchus
The stem and bulb nematode, Ditylenchus dipsaci, is one of the most destructive plant-parasitic nematodes in temperate regions. It infests over 400 plant species, including economically vital crops like onions, garlic, clover, and alfalfa. Unlike root-parasites, Ditylenchus primarily attacks the above-ground parts and bulbs, causing tissue breakdown, swelling, and distortion. Its ability to undergo anhydrobiosis allows it to survive in dried plant material and soil for many years, facilitating its global spread.

152. (A) Forming "nematode wool" resistant to anhydrobiosis
Under conditions of extreme desiccation, Ditylenchus dipsaci juveniles can aggregate in massive numbers to form a visible, whitish, lint-like substance known as "nematode wool." Within these clusters, the nematodes enter a state of anhydrobiosis, where their metabolism is virtually suspended. This adaptation protects them from drying out and allows the population to remain viable for years in a dormant state until moisture returns, ensuring their survival in fluctuating environments.

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153. (D) Seed heads and foliage, forming distinct galls
Nematodes of the genus Anguina are primarily specialized parasites of the aerial parts of plants, particularly grasses and cereals. They are best known for inducing the formation of galls in the seed heads (kernels) and sometimes on the leaves and stems. The juveniles enter the developing florets and stimulate the plant to produce a gall instead of a seed. Inside these galls, the nematodes complete their life cycle and can survive for decades in a desiccated state.

154. (B) Carrying Clavibacter bacteria causing yellow ear rot
Anguina tritici has a significant synergistic relationship with the bacterium Clavibacter toxicus (or related species). The nematode acts as an essential vector, carrying the bacteria on its cuticle as it migrates to the developing seed heads of wheat. The bacteria then multiply within the nematode-induced galls, causing a disease known as yellow ear rot or "tundu." This nematode-bacterial complex is much more damaging than either pathogen acting alone, severely reducing crop yields.

155. (A) I and II
Nacobbus, the false root-knot nematode, induces galls that look similar to those caused by Meloidogyne, making statement I correct. Also, mature Nacobbus females have a swollen posterior body but maintain a vermiform anterior end, making statement II correct. However, statement III is false because Nacobbus does not form a cyst; instead, it lays eggs into an external gelatinous matrix, distinguishing it from the cyst-forming nematodes like Heterodera.

156. (C) Morphological traits typical of root-lesion nematodes
Although Nacobbus induces root galls like Meloidogyne, it is classified within the Family Pratylenchidae (the same family as root-lesion nematodes). This placement is based on fundamental morphological characters,

including the structure of the esophagus and the cephalic framework, which more closely resemble Pratylenchus than Meloidogyne. This highlights the importance of using internal anatomy rather than just external symptoms for accurate taxonomic classification in nematology.

157. (D) Paratylenchus
Pin nematodes belong to the genus Paratylenchus. They are among the smallest plant-parasitic nematodes, often measuring less than 0.5 millimeters in length. Despite their small size, they can occur in extremely high populations in the soil. Most species are ectoparasites that feed on root hairs and epidermal cells. Their name "pin nematode" refers to their diminutive size and the relatively long, slender stylet found in the females of many species.

158. (C) An extraordinarily long stylet in relation to its small body size
A striking morphological feature of many Paratylenchus species is the presence of an exceptionally long and robust stomatostylet compared to their tiny body size. In some species, the stylet can be more than one-fifth the total length of the nematode. This long spear allows the tiny nematode to reach and feed on cells deep within the root while remaining on the outside, a highly effective adaptation for its ectoparasitic lifestyle.

159. (B) Tylenchorhynchus
Stunt nematodes belong to the genus Tylenchorhynchus. They are migratory ectoparasites that feed on the roots of a wide variety of plants, particularly grasses and cereals. They are characterized by a well-developed, sclerotized cephalic framework, a robust stylet with distinct knobs, and a tail that is usually blunt or rounded. Their feeding can cause general stunting of the plant and reduced root growth, but they do not induce specialized galls or cysts.

160. (D) Hemicycliophora
Hemicycliophora species are known as sheath nematodes because they retain the old cuticle from the final juvenile moult as a loose, transparent outer sheath around their adult body. This "double-walled" appearance is highly diagnostic. They are relatively large ectoparasites with very long, curved stylets. They feed primarily on root tips, often causing them to swell into terminal galls. The sheath is thought to provide protection and help regulate the nematode's internal environment.

161. (A) Globodera is spherical; Heterodera has a vulval cone
The primary morphological distinction between the two major cyst nematode genera lies in the shape of the mature cyst. Heterodera cysts are typically lemon-shaped and possess a prominent, protruding vulval cone at the posterior end. In contrast, Globodera cysts are more or less spherical and lack a distinct vulval cone. This simple but consistent difference in body shape is the first step in distinguishing these two economically important genera.

162. (C) Globodera rostochiensis
Globodera rostochiensis is commonly known as the golden potato cyst nematode. This name comes from the characteristic color change that the female undergoes as she matures. Before dying and becoming a brown cyst, the female turns a brilliant golden yellow for several weeks while still attached to the potato root. This species is a major quarantine pest worldwide due to the severe yield losses it causes in potato crops.

163. (A) G. pallida stays white; G. rostochiensis turns golden
These two closely related species can be distinguished by the color of the developing females on the host roots. Globodera rostochiensis females pass through a distinct golden yellow phase as they mature. In contrast, Globodera pallida females typically transition directly from white or creamy-white to brown without a yellow stage. This "golden" vs. "pale" difference is a useful field diagnostic for identifying these two major potato pests.

164. (D) Multinucleate syncytia formed by cell wall dissolution
Cyst nematodes (Heterodera and Globodera) induce a specialized feeding site called a syncytium. This structure is formed when the nematode's secretions trigger the dissolution of cell walls between neighboring root cells, allowing their protoplasts to fuse. The resulting large, multinucleate, and metabolically active cell becomes a nutrient sink that provides all the nourishment required for the nematode to complete its life cycle and produce eggs within a protective cyst.

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165. (A) I, II, and IV
Statements I, II, and IV are correct. Meloidogyne induces giant cells via mitosis without cytokinesis, exhibits environmental sex determination (more males in poor conditions), and the J2 stage is the mobile, infective form. Statement III is incorrect because many important root-knot species, like M. incognita and M. javanica, reproduce by obligate mitotic parthenogenesis (asexual reproduction), which allows them to build up large populations very rapidly without the need for males.

166. (C) Meloidogyne incognita
Meloidogyne incognita is considered the most globally significant and damaging root-knot nematode species. It has an incredibly broad host range, attacking thousands of plant species, including most major vegetables, fruits, and field crops. Its ability to reproduce rapidly via parthenogenesis and its adaptation to warm climates make it a primary concern for agriculture in tropical and subtropical regions, where it causes billions of dollars in annual crop losses.

167. (D) A gelatinous matrix of cross-linked glycoproteins
Adult Meloidogyne females secrete a gelatinous matrix, primarily through their rectal glands, which is composed of cross-linked glycoproteins. This matrix forms a protective sac at the posterior end of the female, into which she lays her eggs. The matrix serves several roles: it protects the eggs from desiccation and microbial attack, and it may contain chemical cues that influence the hatching and behavior of the second-stage juveniles (J2).

168. (A) Meloidogyne hapla
Meloidogyne hapla is known as the northern root-knot nematode because it is adapted to cooler climates and can survive freezing soil temperatures. It is distinguished from the tropical species by its smaller size and the characteristic perineal pattern of the female. Additionally, M. hapla typically induces smaller, more discrete galls and often stimulates the production of many fine lateral roots (hairy roots) near the site of infection.

169. (D) Cuticular striae around the vulva and anus of the female
The perineal pattern is a critical diagnostic feature for identifying Meloidogyne species. It consists of the complex arrangement of cuticular ridges and grooves (striae) in the region surrounding the vulva and anus of the mature female. By examining the shape, height, and specific markings of this pattern under a microscope, taxonomists can distinguish between different species, even those that appear identical in other life stages.

170. (B) Distinct lateral incisures in the pattern of M. javanica
A key morphological difference used to separate Meloidogyne javanica from M. incognita is the presence of distinct lateral lines or incisures in the perineal pattern. In M. javanica, these lines clearly divide the dorsal and ventral sections of the pattern. In M. incognita, the lateral incisures are generally absent or very poorly defined, with the striae forming a continuous arch. This feature is a primary tool for distinguishing these two common tropical species.

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171. (A) A species delineated strictly by observable morphological and structural features
A morphospecies is a group of organisms that are classified as a single species based on shared physical characteristics and structural traits. In nematology, this approach relies on detailed microscopic analysis of features such as body size, stylet morphology, and reproductive anatomy. While molecular methods are increasing, the morphospecies remains the practical unit for most taxonomic descriptions and diagnostic keys used in agricultural and ecological research.

172. (C) Principle of Typification
The Principle of Typification, mandated by the ICZN, requires that every named taxon (genus or species) must be anchored by a physical "type" that serves as the objective standard for the name. For a genus, the type is a designated species. This ensures that the scientific name is always linked to a specific biological entity, providing a stable reference point that prevents confusion if the classification of related organisms changes.

173. (D) Debris removal and internal pressure regulation
Coelomocytes are large, specialized cells found within the pseudocoelom of many nematodes. While their exact roles can vary, they are generally thought to function as "scavenger" cells, removing metabolic waste, debris, and potentially pathogens from the body fluid. They may also play a role in maintaining the internal hydrostatic pressure and overall homeostasis of the nematode's internal environment by regulating the composition of the pseudocoelomic fluid.

174. (C) Central integration center encircling the esophagus
The nerve ring, or circumpharyngeal commissure, is the central processing unit of the nematode nervous system. It consists of a dense ring of nerve fibers and associated ganglia that encircles the esophagus, usually near the level of the isthmus. It receives sensory information from the head (via amphids and papillae) and coordinates motor outputs to the longitudinal muscles, allowing the nematode to respond to environmental stimuli and navigate its surroundings.

175. (B) I, III, and IV
Statements I, III, and IV are correct. Moulting is hormonally regulated, lethargus is the quiescent period before shedding, and exsheathment is the process of leaving a retained cuticle. Statement II is incorrect because nematodes are eutelic, so growth in adults occurs through cell enlargement, not rapid cell division. Statement V is incorrect because J4 juveniles possess developing reproductive structures that become functional after the final moult into the adult stage.

176. (D) Migratory endoparasite - Radopholus
Radopholus similis is a classic example of a migratory endoparasite. Both the juveniles and the adult females enter the root tissue and move freely through the cortex, feeding on cells and causing extensive tunneling and necrosis. Unlike sedentary parasites like Meloidogyne (root-knot) or Heterodera (cyst), Radopholus does not establish a permanent feeding site and remains motile throughout its life, continually moving to fresh tissue as the host cells are destroyed.

177. (A) Phasmids (scutella)
Scutellonema is a genus of spiral nematodes characterized by possessing exceptionally large, shield-like phasmids, which are often called "scutella." These sensory organs are much larger than those found in most other nematodes and are located on the lateral fields near the tail region. The presence and size of these scutella are diagnostic for the genus and are easily visible under a light microscope, facilitating rapid identification in soil samples.

178. (C) Heavily sclerotized retrorse cuticular annulations
Criconemoides and other ring nematodes possess a unique cuticle with deep, backward-projecting (retrorse) annulations that are heavily sclerotized. This structural adaptation provides exceptional physical protection and allows the nematode to withstand the significant pressure of moving through dense soil. The retrorse shape of the annules also provides traction, enabling the nematode to push through soil pores by expanding and contracting its body in a powerful, telescopic manner.

179. (A) Synergistic disease complex (nematode-fungus complex)
The interaction between Meloidogyne incognita and Fusarium oxysporum is a well-documented example of a synergistic disease complex. The nematode damage predisposes the plant to fungal infection, and together they cause much more severe disease symptoms (such as wilt and stunting) than either pathogen alone. The nematode's feeding creates entry points for the fungus and alters host physiology in ways that favor fungal colonization, leading to catastrophic crop damage.

180. (D) Wounding provides entry pathways and nutrient sinks
Nematode feeding activities significantly predispose plants to secondary fungal infections. The mechanical wounding caused by the stylet during penetration and migration provides direct entry points for soil-borne fungi. Furthermore, the specialized feeding sites (giant cells or syncytia) induced by nematodes act as powerful nutrient sinks, drawing resources away from the plant's defense systems and creating a nutrient-rich environment that promotes the rapid growth and spread of fungal pathogens.

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181. (B) Ribosomal DNA ITS regions with restriction digests
For differentiating species within the Bursaphelenchus xylophilus complex, analyzing the ITS regions of ribosomal DNA using restriction enzyme digests (PCR-RFLP) is a highly effective molecular tool. The ITS region contains enough sequence variation to provide species-level resolution, and the resulting restriction fragment patterns provide a clear, standardized "fingerprint." this method allows for the rapid and reliable identification of these morphologically similar but ecologically distinct and quarantine-significant nematodes.

182. (C) High intraspecific plasticity blurs species boundaries
A major challenge in morphology-based taxonomy for genera like Pratylenchus is high intraspecific plasticity. Individual nematodes within the same species can show significant variation in traits like body length, tail shape, and number of annules due to environmental factors or different hosts. This variability often overlaps with the characteristics of other species, making it difficult to define clear morphological boundaries and necessitates the use of molecular tools to achieve accurate and reliable identifications.

183. (D) Morphologically indistinguishable but genetically divergent
Cryptic species are groups of organisms that appear virtually identical in their physical morphology but are genetically distinct and reproductively isolated. In nematology, the discovery of cryptic species is common as molecular techniques advance. These species may have very different host ranges, geographical distributions, or environmental tolerances. Recognizing cryptic species is vital for effective pest management, as strategies effective against one morphotype may fail against its genetically different, cryptic counterpart.

184. (A) The 28S large subunit rRNA gene
In nematode molecular diagnostics, the D2/D3 expansion segments are specific, highly variable regions located within the 28S large subunit ribosomal RNA gene. These segments provide an excellent balance of conserved and variable sequences, making them ideal for identifying nematodes at the genus and species levels. Sequencing these regions is now a standard practice in nematology for verifying morphological identifications and reconstructing phylogenetic relationships among diverse nematode groups.

185. (D) To designate a type specimen from original syntypes
In older taxonomy, species were often described from a series of specimens (syntypes) without a single holotype being chosen. A lectotype is a single specimen subsequently selected from that original syntype series to serve as the unique name-bearing type. This process, governed by ICZN rules, provides a definitive standard for the species name, which is essential for resolving taxonomic confusion when the original series contains more than one species.

186. (B) It prevents regurgitation of intestinal contents
The esophago-intestinal valve, or cardia, is located at the junction of the esophagus and the intestine. Its primary physiological function is to act as a one-way valve, preventing the regurgitation of food and digestive enzymes from the intestine back into the esophagus. This is especially important given the high internal hydrostatic pressure of the nematode body, which would otherwise force the intestinal contents out through the mouth.

187. (A) The muscular median bulb
In a tylenchoid esophagus, the metacorpus is the specialized, muscular median bulb. It typically contains a central valvular apparatus composed of crescentic plates. The metacorpus functions as a powerful suction and pressure pump, drawing food into the mouth via the stylet and then forcing it past the isthmus into the intestine for digestion. The presence and morphology of the metacorpus are key diagnostic features for classifying nematodes within the Order Tylenchida.

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188. (C) Secreting enzymes to facilitate root penetration
During the initial stages of infection, the two subventral esophageal glands of plant-parasitic nematodes are highly active. They produce and secrete a suite of cell-wall-degrading enzymes, such as cellulases, pectinases, and hemicellulases. These enzymes are injected into the host tissue via the stylet, where they soften and dissolve the plant cell walls. This biochemical activity allows the nematode to mechanically penetrate the root

and migrate through the tissue with minimal energy expenditure.

189. (D) Effector protein secretion to induce feeding cells
Once a plant-parasitic nematode has reached its permanent feeding site, the dorsal esophageal gland becomes the primary source of secreted effectors. These specialized proteins are injected into a single host cell to reprogram its metabolism and development. This molecular manipulation leads to the formation of multinucleate feeding cells, such as giant cells or syncytia, which serve as the long-term nutrient source required for the nematode's sedentary growth and reproduction.

190. (C) Cell wall dissolution between adjacent root cells
A syncytium, induced by cyst nematodes (Heterodera and Globodera), is a complex feeding structure formed by the fusion of hundreds of host cells. The nematode injects effectors that stimulate the partial dissolution of cell walls between the initial feeding cell and its neighbors. This allows the cytoplasm of adjacent cells to merge into a single, large, multinucleate metabolic sink. The syncytium provides the continuous supply of nutrients needed for the nematode to develop into a mature, egg-producing female.

191. (B) Continuous rounds of mitosis uncoupled from cytokinesis within a discrete cell
Root-knot nematodes (Meloidogyne) induce the formation of specialized "giant cells" as their feeding sites. Unlike syncytia, giant cells are formed when a small number of discrete host cells undergo repeated rounds of DNA replication and mitosis without the corresponding cell division (cytokinesis). This process, known as endoreduplication, results in massive, multinucleate cells with extremely high metabolic activity, which provide the sedentary female with the vast amount of nutrients required for egg production.

192. (D) They are metabolically active sinks with dense cytoplasm
Both syncytia and giant cells are highly specialized, living tissues characterized by extreme metabolic activity. They feature dense, granular cytoplasm, an increased number of organelles (like mitochondria and ribosomes), and multiple, enlarged nuclei. These cellular modifications are designed to maximize nutrient synthesis and transport to the nematode. Functioning as powerful metabolic sinks, these feeding sites divert the plant's resources away from growth and defense to sustain the parasite.

193. (A) Secretions explicitly injected from the nematode's esophageal glands
When feeding on host cells, many plant-parasitic nematodes, particularly Heterodera, form "feeding tubes" within the host cytoplasm. These tubes are not plant-derived; rather, they are structural assemblies formed by the rapid polymerization of proteins secreted from the nematode's esophageal glands. These tubes act as specialized filters, allowing the nematode to selectively ingest small molecules and nutrients while preventing the intake of large cellular components that might clog its narrow feeding spear.

194. (C) Adenophorea
In the classical classification system by Chitwood, the Class Adenophorea (meaning "gland bearers") was primarily characterized by the presence of large, well-developed, and often diversely shaped amphids. These sensory organs are frequently spiral, circular, or pocket-like in Adenophoreans, compared to the small, pore-like amphids typically found in the Class Secernentea. This difference in amphid morphology was a fundamental trait used to distinguish these two major groups of nematodes before the era of molecular phylogenetics.

195. (A) Both A and R are true and R is the correct explanation of A.
Identifying many nematode species requires the resolution provided by scanning electron microscopy (SEM). Features such as the exact arrangement of lip sectors, the fine structure of the amphidial apertures, and subtle cuticular patterns are often too small to be accurately seen with light microscopy. SEM provides high-resolution, three-dimensional views of the nematode's surface, which are essential for defining modern taxonomic boundaries and identifying species within complex genera like Meloidogyne or Pratylenchus.

196. (D) A frontal view of the head to observe lip arrangements
An "en face" view is a specialized technique in nematode morphology where the specimen's

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head is oriented to face the observer directly. This allows for the detailed examination of the oral opening, the arrangement of the lips (usually six in the ancestral state), and the placement of cephalic papillae and amphids. This frontal perspective is crucial for taxonomic classification, as the symmetry and structure of the head region are stable diagnostic characters across various nematode orders.

197. (B) Six distinct lips (two subdorsal, two lateral, two subventral)
The ancestral or "basic" arrangement of the nematode labial region consists of six distinct lips surrounding the mouth: two subdorsal, two subventral, and two lateral. Each lip typically bears specialized sensory papillae. While many modern nematode groups have undergone lip fusion (resulting in three or even zero distinct lips), this hexaradiate symmetry remains the foundational model for understanding the evolution and diversity of the nematode head region across different taxonomic groups.

198. (C) Sclerotized internal head support in Tylenchida
The cephalic framework is a heavily sclerotized, internal cuticular structure found in the head region of many nematodes, particularly within the Order Tylenchida. It provides structural support for the head and serves as a rigid anchor for the protractor muscles that power the stylet. The degree of sclerotization and the shape of the framework (often seen as a "skeleton" in the head) are important diagnostic features used for identifying genera and species.

199. (D) Transverse continuation of annulations across the field
Areolation is a specific morphological condition where the transverse annulations of the nematode cuticle extend across the longitudinal incisures of the lateral field. This breaks the smooth longitudinal lines into a series of small, block-like rectangles. The presence of areolation, and whether it occurs along the entire body or is restricted to the anterior or posterior regions, is a significant taxonomic character used to distinguish between different nematode species and genera.

200. (A) The fusion of male and female gametes to form a zygote
Syngamy is the fundamental process of sexual reproduction where a male gamete (sperm) fuses with a female gamete (egg) to form a diploid zygote. This ensures genetic recombination and diversity within a population. In nematodes, syngamy is the standard mode of reproduction for many free-living and parasitic species, requiring both males and females to be present in the environment for successful population growth and survival.

201. (D) Protandrous
Protandrous hermaphroditism is a reproductive strategy where an individual produces sperm first, which is then stored in a specialized spermatheca. Subsequently, the same gonad matures and begins producing oocytes. As the eggs pass through the spermatheca, they are fertilized by the stored sperm. This allows a single individual to reproduce without a mate, a highly effective adaptation for colonizing new environments, as seen in the model nematode Caenorhabditis elegans.

202. (B) Obligate mitotic parthenogenesis
The highly successful root-knot nematode, Meloidogyne incognita, reproduces primarily via obligate mitotic parthenogenesis. In this asexual process, the oocytes undergo mitosis without meiosis, resulting in offspring that are genetically identical clones of the mother. This allows the nematode to build up massive populations extremely quickly on a suitable host, as every individual in the population is an egg-producing female, and no energy is wasted on male production or finding mates.

203. (A) Clonal reproduction resulting in offspring genetically identical to the mother
Mitotic parthenogenesis is an asexual reproductive strategy where offspring develop from unfertilized eggs that have not undergone meiosis. This results in the production of clones that are genetically identical to the mother. This strategy is advantageous for sedentary parasites in stable environments, as it allows for rapid population growth and the maintenance of highly adapted genetic lineages without the need for males or the risks associated with sexual recombination.

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204. (C) Oocytes undergo meiosis and diploidy is restored
Meiotic parthenogenesis is a form of asexual reproduction where oocytes undergo meiosis, but the diploid number of chromosomes is subsequently restored without fertilization. This can occur through the fusion of the egg nucleus with a polar body or by doubling the chromosomes before or after meiosis. While it is asexual, it allows for some degree of genetic recombination, providing a balance between the rapid population growth of parthenogenesis and the genetic flexibility of sexual reproduction.

205. (A) P-2, Q-1, R-4, S-3
Nematodes exhibit diverse reproductive strategies. Amphimixis is standard sexual reproduction involving sperm and egg fusion. Parthenogenesis is reproduction without fertilization. Hermaphroditism involves a single individual producing both sperm and eggs. Pseudogamy, or gynogenesis, occurs when sperm penetration is required to stimulate egg development, but the male's genetic material is not incorporated into the zygote. These strategies allow nematodes to adapt to a wide range of ecological niches and host availabilities.

206. (C) Fluid pressure against the robust, layered cuticle
The characteristic cylindrical, vermiform shape of nematodes is maintained by a hydrostatic skeleton. This system relies on the high pressure of the fluid within the pseudocoelom, which pushes outward against the strong, elastic, and multi-layered cuticle. This internal turgor pressure provides the structural rigidity necessary for the nematode to move and function, effectively acting as an antagonist to the longitudinal muscles and maintaining the organism's shape without an internal bony framework.

207. (B) An extraordinarily long, curved stylet and an extra cuticular sheath
The genus Hemicycliophora is easily recognized by its unique "sheath nematode" morphology. Adult females possess an extra cuticular layer, retained from the final juvenile moult, which loosely surrounds the body like a transparent bag. Additionally, they are characterized by an exceptionally long and often ventrally curved stomatostylet. These large ectoparasites primarily feed on root tips, often inducing the formation of characteristic terminal galls on the roots of their host plants.

208. (D) Flooded rice paddies
Hirschmanniella species, known as rice root nematodes, are major pests of rice, particularly in flooded or irrigated systems. They are highly adapted to aquatic environments and can move through the water-filled soil to infect rice roots. By feeding as migratory endoparasites within the root cortex, they cause extensive necrosis and reduce nutrient uptake, leading to significant yield losses in rice-growing regions worldwide. Their ability to survive in water makes them a persistent threat.

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209. (A) Migratory endoparasite
Hirschmanniella is a genus of migratory endoparasitic nematodes. Both the juveniles and adults enter the root tissue and move freely through the cortex, feeding on cells as they go. Unlike sedentary parasites, they do not establish a fixed feeding site. Their constant movement and feeding cause extensive internal damage and necrosis, which impairs root function and predisposes the plant to secondary infections, making them highly destructive pests of various aquatic and semi-aquatic crops, including rice.

210. (C) Belonolaimus
The genus Belonolaimus consists of the "sting nematodes," which are among the most destructive ectoparasitic nematodes in sandy soils. They are characterized by their relatively large size and an exceptionally long, needle-like stylet. By feeding deep within root tips, they cause severe stunting, necrosis, and "sting" symptoms, where roots fail to elongate. Their preference for coarse, sandy soils makes them a major pest in regions with such soil types, particularly in the southeastern United States.

211. (A) Head region divided into four distinct lobes
A key diagnostic feature for identifying members of the genus Belonolaimus is the morphology of the head. When viewed under a microscope, the cephalic region is clearly divided into four distinct lobes by deep longitudinal grooves. This "four-lobed" head, combined with a very long stylet and a relatively large, slender body, is highly characteristic. This structural detail allows taxonomists to reliably distinguish sting nematodes from other similar-

looking ectoparasitic genera like Longidorus or Xiphinema.

212. (B) Significant morphological differences between males and females of the same species
Sexual dimorphism is common in many nematode groups, where males and females exhibit very different physical characteristics. For example, in Meloidogyne (root-knot) and Heterodera (cyst) nematodes, the infective juveniles are vermiform, but the mature females become swollen and sedentary. In contrast, the adult males remain vermiform and motile. This difference in shape, along with variations in stylet size and reproductive organs, is a fundamental aspect of nematode biology and a critical factor in taxonomic identification.

213. (B) Cloaca
In male nematodes, the posterior end of the digestive tract and the reproductive system merge into a single common chamber known as the cloaca. This structure receives both fecal matter from the rectum and sperm from the vas deferens. The cloaca opens to the exterior through a cloacal pore. This shared exit is also the site where the male's specialized copulatory organs, such as spicules and the gubernaculum, are located and utilized during mating.

214. (D) The gubernaculum
The titillum is a small, specialized cuticular projection or modification sometimes found on the gubernaculum in certain male nematodes. As the gubernaculum serves to guide the spicules during copulation, the titillum is thought to provide additional support or sensory feedback during the mating process. While not present in all species, the morphology of the gubernaculum and its associated structures like the titillum are important diagnostic characters used in the taxonomic classification of male nematodes.

215. (D) The flared, proximal head-like base of the spicule
The capitulum is the expanded, often head-like proximal end of the male spicule. It serves as the primary attachment point for the muscles that control the protrusion and retraction of the spicule during copulation. The specific shape and size of the capitulum, along with the overall morphology of the spicule shaft and tip, are highly species-specific and are essential diagnostic features used by taxonomists to identify and classify male nematodes.

216. (A) Bottle-shaped esophagus and sensory arrangements
The Order Dorylaimida is placed within the Class Enoplea based on its ancestral morphological characteristics. Key features include the "bottle-shaped" esophagus, which lacks a valvular median bulb, and the presence of large, pouch-like amphids. These traits are considered more primitive compared to the derived pore-like amphids and complex esophageal bulbs found in the Class Chromadorea. This phylogenetic position is strongly supported by molecular data, placing dorylaimids near the base of the enoplean lineage.

217. (D) Recent speciation or high morphological plasticity
When two nematode populations show nearly identical ITS sequences but significant morphological differences, it often indicates either recent speciation or high morphological plasticity. Recent speciation occurs when populations have diverged physically before enough time has passed for substantial genetic changes to accumulate in conserved regions. Alternatively, high plasticity means that a single species can develop different physical forms in response to varied hosts or environmental conditions, challenging traditional morphology-based taxonomy.

218. (B) Lacks introns and features a relatively fast mutation rate
Targeting the mitochondrial COI gene is a standard practice because it lacks introns and has a relatively fast mutation rate compared to nuclear genes. This provides sufficient variation to distinguish between closely related species. Furthermore, mitochondria are present in many copies per cell, making it easier to amplify DNA from small or degraded samples. These factors make the COI gene a powerful and efficient molecular tool for nematode barcoding and species-level identification.

219. (A) Closely related species that are morphologically cryptic
A "superspecies" or species complex in nematology refers to a group of very closely related species that are difficult or impossible to distinguish using traditional morphological

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characters alone. These are often referred to as cryptic species. The Meloidogyne incognita group is a classic example, where several genetically distinct lineages cause similar symptoms and appear identical under a microscope. Recognizing these complexes is vital for precise research and developing targeted, effective pest management strategies.

220. (B) Extraction & Observation → DNA Sequencing → Designation of Type Specimens → Manuscript Publication
The formal description of a new nematode species follows a logical scientific progression. It begins with the extraction and microscopic observation of the specimens. Modern taxonomy then integrates DNA sequencing to provide molecular evidence. Once the species is confirmed as new, the researcher designates type specimens (holotype and paratypes) for permanent storage. Finally, the description and name are formally published in a peer-reviewed manuscript, ensuring the name is available according to ICZN rules.

221. (D) The Principle of Coordination
The Principle of Coordination is a core ICZN rule stating that establishing a name in any rank within the family group (e.g., family, subfamily) automatically establishes coordinate names at the other ranks within that group, with the same author and date. This principle ensures consistency in the naming of higher-level taxa and simplifies the taxonomic hierarchy, helping maintain stability as nematodes are reclassified into different subfamilies or families over time.

222. (C) The corresponding coordinate nominal taxa with same author
Under the ICZN's Principle of Coordination, the establishment of a new family name automatically creates coordinate taxa at other levels within the family group, such as subfamilies and superfamilies, all attributed to the same original author and date. This rule ensures that the entire hierarchical structure within that group is linked and consistent, facilitating stable nomenclature even if the rank of the group is later changed by other researchers.

223. (A) 1 January 1758
The "Law of Priority" in zoological nomenclature, including nematology, only applies to names published after 1 January 1758. This date corresponds to the publication of the tenth edition of Carl Linnaeus's Systema Naturae, which is the official starting point for modern binomial nomenclature. Any names proposed before this date have no standing in modern taxonomy, ensuring a clear and stable historical baseline for all scientific animal names.

224. (D) The description is inadequate and the type is lost
A "nomen dubium" is a scientific name of unknown or doubtful application. This typically occurs in older nematological literature where the original species description is too brief or vague to allow for certain identification, and the original type specimens have been lost or destroyed. Because it is impossible to determine exactly which biological entity the author intended, the name cannot be reliably used, and it remains a "doubtful name" in the taxonomic record.

225. (A) Has been published without an accompanying description, definition, or indication to make it available
A "nomen nudum" is a proposed scientific name that fails to meet the ICZN requirements for availability because it was published without a proper description, definition, or reference to such a description. In nematology, this often happens when a name is used in a meeting abstract or a checklist before the formal species description is published. Such names have no standing in taxonomy and cannot be used until they are validly described.

226. (C) It bridges temporal gaps in food availability and barriers
The dauer larval stage is a key evolutionary adaptation that allows nematodes to survive unfavorable environmental conditions. By entering a state of developmental arrest and metabolic suppression, the nematode can bridge temporal gaps when food is scarce or environmental stress is high. Furthermore, the specialized cuticle and behavioral changes of the dauer stage often facilitate dispersal by insect vectors, allowing the nematode to cross physical barriers and colonize new, more favorable habitats.

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227. (A) The developmentally arrested dauer stage (J3)
In entomopathogenic nematodes like Steinernema and Heterorhabditis, the infective juvenile (IJ) is a specialized third-stage larva (J3). It is functionally and structurally analogous to the dauer larva of Caenorhabditis elegans. The IJ is adapted for long-term survival in the soil and is the only stage capable of infecting a new insect host. Upon entering a host, the IJ resumes development, moulting into the fourth juvenile stage and eventually becoming a reproductive adult.

228. (D) Retention of the J2 cuticle as an environmental sheath
The infective juvenile (IJ) of entomopathogenic nematodes is often characterized by the retention of the cuticle from the second juvenile stage (J2) as an extra outer sheath. This "ensheathed" state provides an additional layer of protection against environmental stressors such as desiccation, extreme temperatures, and chemical toxins in the soil. This adaptation significantly enhances the longevity and survival of the IJ while it searches for a suitable insect host to parasitize.

229. (B) The shedding of a retained cuticular sheath in response to cues
Exsheathment is the physiological process where a nematode sheds a retained juvenile cuticle, such as the J2 sheath of an infective juvenile. This process is triggered by specific environmental or host-derived cues, such as temperature changes or chemical signals from a potential host. In entomopathogenic and animal-parasitic nematodes, exsheathment is a critical first step in the infection process, allowing the nematode to become active and penetrate the host's body.

230. (A) 2 - 3 - 4 - 1
The application of molecular tools in nematology has evolved from early protein-based methods to modern genomics. The sequence began with allozyme electrophoresis in the 1970s and 80s, followed by the development of PCR-based RFLP in the 1990s. Direct DNA sequencing of ITS and other regions became standard in the 2000s. Currently, whole genome sequencing (WGS) represents the cutting edge of the field, providing unprecedented detail for taxonomic and evolutionary studies.

231. (D) RFLP uses enzyme patterns; sequencing reads exact code
PCR-RFLP and direct DNA sequencing are both used for species identification but differ in their approach. RFLP relies on restriction enzymes to cut DNA into specific fragments, creating a banding pattern or "fingerprint" that reflects the presence or absence of specific sequences. In contrast, direct sequencing reads the exact order of every nucleotide in the DNA strand. While RFLP is faster and cheaper for routine screening, sequencing provides the ultimate level of genetic resolution.

232. (A) Retrorse annules and an open vulva lacking lateral flaps
Macroposthonia, a genus of ring nematodes, is identified by its criconematid features, including deep, retrorse (backward-pointing) cuticular annules. A key diagnostic trait for this genus is the morphology of the female vulva, which is typically open and lacks the prominent lateral flaps seen in some other related genera. These stable cuticular characters are essential for distinguishing between the various genera of ring nematodes, which often appear superficially similar during soil sample processing.

233. (B) Spiral nematode
Helicotylenchus species are commonly known as spiral nematodes. This name refers to their characteristic habit of coiling into a tight spiral or "C" shape when they are relaxed, inactive, or heat-killed. This behavioral and morphological trait is very consistent and is used by nematologists as a primary diagnostic character for rapid identification in soil samples. They are common ectoparasites or semi-endoparasites on a vast range of plants worldwide.

234. (B) The tail length
In de Man's morphometric system, the c ratio is calculated by dividing the total body length by the tail length. Therefore, a high degree of variation in the c value within a population directly implies that there is significant variability in the relative length of the tail. This variation can be due to environmental factors, host effects, or natural biological diversity within the species, and it highlights the importance of measuring multiple individuals to establish a reliable taxonomic range.

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235. (A) Contraction of the esophageal region during fixation
De Man's b index represents the ratio of total body length to esophageal length. This value is particularly sensitive to fixation artifacts because the esophageal region, which is rich in muscle, often contracts more than the rest of the body when the nematode is killed. This can lead to an underestimation of the true esophageal length and an artificially high b value. Taxonomists must use standardized, gentle killing and fixing methods to minimize these errors.

236. (C) Alpha names species; Beta arranges species into genera
In the hierarchy of taxonomy, Alpha taxonomy is the foundational level concerned with the discovery, description, and naming of individual species. Beta taxonomy, also known as macro-taxonomy, takes these species and organizes them into a hierarchical system of higher-level groups, such as genera, families, and orders. While Alpha taxonomy provides the basic units, Beta taxonomy focuses on the relationships and evolutionary classification of those units within the broader biological framework.

237. (D) Number and arrangement of muscle cells per quadrant
The classification of nematode somatic musculature into holomyarian, meromyarian, and polymyarian types is based strictly on the number and arrangement of longitudinal muscle cells within each body quadrant. Holomyarian nematodes have a continuous layer of muscles. Meromyarian types have only two to five cells per quadrant, common in small nematodes. Polymyarian types have numerous cells projecting into the pseudocoelom, which is typical of larger nematodes like Ascaris. This reflects different mechanical requirements for movement.

238. (C) Numerous muscle cells extending into the body cavity
In a polymyarian muscle arrangement, which is common in large nematodes, a cross-section reveals many narrow longitudinal muscle cells in each quadrant. The contractile portion of each cell is located against the hypodermis, while the large, non-contractile part, containing the nucleus, projects significantly into the pseudocoelomic fluid. This arrangement provides the massive muscle power needed to move a large body against environmental resistance, a feature easily visible under microscopic examination.

239. (B) The median bulb (metacorpus), when heavily muscularized
In most Secernentean nematodes, the median bulb or metacorpus acts as the primary pump for food ingestion. This bulb is heavily muscularized and contains a central valvular apparatus with crescentic plates. By rapidly contracting and relaxing its radial muscles, the metacorpus creates the suction needed to draw liquid or particulate food through the mouth and stylet. It then forcefully pumps the food past the isthmus and into the intestine for digestion.

240. (D) Cortical migration causing extensive necrotic lesions
Pratylenchus species, the root-lesion nematodes, are migratory endoparasites. They enter host roots and move continuously through the cortical tissue, using their stylet and cell-wall-degrading enzymes to destroy and feed on cells. This constant migration and feeding result in the formation of extensive necrotic lesions within the root. Unlike root-knot nematodes, they do not become sedentary or induce specialized feeding cells, making their impact primarily mechanical and destructive to the root system.

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241. (A) Interbreeding natural populations reproductively isolated
The Biological Species Concept (BSC) defines a species as a group of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups. In nematology, this means that individuals belonging to the same species can produce viable, fertile offspring with each other but not with members of a different species. This concept focuses on gene flow and reproductive barriers as the primary criteria for defining the boundaries of a species.

242. (B) Because many species reproduce via obligate parthenogenesis
The Biological Species Concept is difficult to apply in agricultural nematology because many economically important species, like Meloidogyne incognita, reproduce through obligate mitotic parthenogenesis (asexual reproduction). Since these organisms do not engage in sexual reproduction, the criterion of "interbreeding" is not applicable. In such cases, taxonomists must

rely on other concepts, such as the morphological or phylogenetic species concepts, to define and identify species based on physical traits or genetic divergence.

243. (A) The Ecological Species Concept
The Ecological Species Concept defines a species as a set of organisms adapted to a particular set of resources, called a niche, in the environment. In nematology, this is applied when species are distinguished primarily by their host range, geographical distribution, or environmental preferences. If two groups of nematodes look similar but consistently occupy different ecological roles or attack different host plants, they may be recognized as distinct species under this ecological framework.

244. (D) It differentiates cryptic species and parthenogenetic groups
The Phylogenetic Species Concept (PSC), which uses molecular data to define species as the smallest diagnosable monophyletic group, is highly valuable in nematology. Its primary advantage is the ability to differentiate cryptic species—groups that appear morphologically identical but are genetically distinct. Furthermore, the PSC provides a robust framework for identifying and classifying parthenogenetic (asexual) nematodes, which cannot be defined by the biological species concept because they do not interbreed.

245. (B) PCR amplification of a specific target gene region
After extracting a single nematode for molecular analysis, the first essential step is the PCR amplification of a specific target gene, such as the ITS, 18S, or COI region. This process creates millions of copies of the target DNA, providing enough material for subsequent analysis. PCR is the foundation of modern molecular nematology, allowing researchers to identify unknown specimens from very small amounts of tissue, such as a single juvenile or even a fragmented individual.

246. (C) Helical collagen fibers of the cuticle
The nematode cuticle contains highly organized layers of collagen fibers, often arranged in a helical or geodesic pattern. These fibers provide exceptional tensile strength and act as a structural constraint. When the internal hydrostatic pressure of the pseudocoelom increases, these helical fibers prevent the nematode from expanding excessively in diameter. This allows the internal pressure to be translated into longitudinal rigidity, which is essential for the nematode's characteristic undulatory locomotion and structural integrity.

247. (D) Fusing or branching of longitudinal cuticular incisures
In the context of the nematode lateral field, anastomosis refers to the irregular fusing, branching, or cross-connection of the longitudinal cuticular incisures. While most species have a consistent number of parallel lines in their lateral field, some groups show these complex patterns. The presence and frequency of anastomosis can be important taxonomic characters used by specialists to differentiate between closely related species and to understand the range of morphological variation within a particular genus.

248. (A) 6 inner labial papillae, 6 outer labial papillae, and 4 cephalic papillae
The ancestral or "basic" arrangement of cephalic sensory organs in nematodes follows a $6 + 6 + 4$ pattern. This consists of an inner ring of six labial papillae (one on each lip), an outer ring of six labial papillae, and a final circle of four cephalic papillae (two subdorsal and two subventral). This hexaradiate symmetry is a fundamental organizational plan in nematodes, although it is often modified through the fusion or loss of structures in many specialized taxa.

249. (D) Amphids - primarily chemoreception
Amphids are the most complex and important sensory organs in nematodes, acting primarily as chemoreceptors. They allow the nematode to detect and respond to chemical gradients in its environment, such as root exudates from host plants or pheromones from potential mates. While nematodes possess other sensory structures like deirids (mechanoreceptors) and phasmids (chemo/mechanoreceptors), the amphids are the central organs for chemical sensing, which is vital for the survival and reproductive success of all nematodes.

250. (B) At the junction of the basal esophageal bulb and the intestine
The cardia, or esophago-intestinal valve, is located at the junction where the basal bulb of the esophagus meets the anterior end of the intestine. This structure often includes small "cardiac

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glands" that may secrete digestive enzymes. The cardia functions as a one-way valve, allowing food to pass into the intestine while preventing regurgitation due to high internal body pressure. Its morphology is a useful taxonomic character for distinguishing between different nematode groups and orders.

251. (A) Barrier preventing regurgitation of intestinal contents
The primary physiological role of the esophago-intestinal valve is to act as a one-way barrier. Because nematodes maintain high internal hydrostatic pressure within their body cavity, food and fluids would naturally be forced back out through the mouth if not for this valve. By preventing regurgitation, the valve ensures that ingested nutrients remain in the intestine for digestion and absorption, which is critical for the nematode's energy balance and overall survival.

252. (C) Consists of a capillary tube surrounded by gland cells
A stichosome is a specialized esophageal structure found in certain nematode orders, such as Trichinellida. It consists of a long, narrow capillary tube that is surrounded by a single row of large, glandular cells called stichocytes. These cells produce secretions that are discharged into the esophageal lumen. The stichosome replaces the muscular bulbs found in other nematodes and is a highly diagnostic morphological feature used to identify these specialized animal-parasitic and sometimes soil-dwelling groups.

253. (D) Trichinellida
The Order Trichinellida is classically characterized by possessing a stichosome esophagus. This group includes significant human and animal parasites, such as Trichinella spiralis (the cause of trichinosis) and Trichuris species (whipworms). The stichosome, with its characteristic row of stichocytes, is a unique and defining morphological trait for this order. While most members are parasitic, their distinct anatomy and evolutionary history are of great interest to both medical parasitologists and systematic nematologists.

254. (C) Males, combining the digestive (hindgut) and reproductive tracts
In male nematodes, a cloaca is the common chamber where both the digestive tract (via the rectum) and the reproductive tract (via the vas deferens) terminate. This shared opening allows for the exit of both waste and sperm. Females, in contrast, typically have a separate anus for digestion and a vulva for reproduction. The presence of the cloaca in males is also the location for specialized copulatory structures like spicules, which are used during mating.

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255. (A) Both A and R are true and R is the correct explanation of A.
Radopholus similis, the burrowing nematode, is a devastating pathogen of bananas worldwide. It migrates through the root cortex, feeding on and destroying cells, which leads to extensive necrosis and large cavities. This massive destruction of root tissue severely weakens the plant's anchorage in the soil. Consequently, the heavy banana plants often fall over during high winds or simply under their own weight, a phenomenon known as "toppling disease" or "uprooting disease."

256. (D) Structural swelling of roots forming irregular galls
The definitive symptom of an advanced Meloidogyne infection is the presence of irregular, structural swellings on the roots, known as galls or knots. These galls are formed as a result of both cell enlargement (hypertrophy) and increased cell division (hyperplasia) triggered by the nematode's secretions. These knots significantly disrupt the plant's vascular system, impairing the uptake of water and nutrients and leading to stunting, yellowing, and reduced yields in susceptible host crops.

257. (A) Galls are structural root swelling; nodules are lateral appendages
It is important to distinguish between nematode galls and bacterial nodules. Galls caused by Meloidogyne are integral, structural swellings of the root axis itself, formed by the expansion of the root's own tissues. In contrast, Rhizobium nodules are distinct, lateral appendages that are attached to the root surface and can be easily snapped off. Furthermore, nodules are typically pinkish inside due to leghaemoglobin, whereas nematode galls usually have the same internal color as the root.

258. (C) modified, metabolically active cortical "nurse cells"
The citrus nematode, Tylenchulus semipenetrans, establishes a specialized feeding site consisting of

a group of modified cortical cells known as "nurse cells." Unlike the giant cells or syncytia induced by other nematodes, these nurse cells remain as discrete, uninucleate units but become highly metabolically active with dense cytoplasm and enlarged nuclei. These cells provide a constant supply of nutrients to the semi-endoparasitic female, which remains partially embedded in the root tissue throughout her life.

259. (A) Inward migration of cell lineages to form the gut tube
Gastrulation is a critical phase in nematode embryogenesis where the blastomeres undergo organized movements to establish the primary germ layers. The primary event is the inward migration (invagination) of specific cell lineages, particularly the E blastomere, which will eventually form the epithelial lining of the intestine. This process transforms the simple ball of cells (blastula) into a more complex structure with internal and external layers, laying the foundation for the nematode's entire body plan.

260. (D) It is the initial form prior to the first moult
The first-stage juvenile (J1) is the developmental form that emerges after the completion of embryogenesis within the egg. In many plant-parasitic nematodes, the J1 is short-lived and undergoes its first moult into the J2 stage while still inside the eggshell. Because the J1 is typically a non-feeding and non-infective stage, it is rarely seen in soil samples. The transition from J1 to J2 is the first major milestone in the post-embryonic life of the nematode.

261. (B) Cryptobiosis or anhydrobiosis
Cryptobiosis is a state where a nematode's metabolic activity is reduced to an undetectable level in response to extreme environmental stress, such as desiccation (anhydrobiosis) or freezing (cryobiosis). In this dormant state, the nematode can survive for years, resisting conditions that would be lethal to active individuals. This remarkable ability allows certain species to persist in harsh or fluctuating environments and facilitates their long-distance dispersal through dried plant material, soil, or wind.

262. (C) Trehalose
During the onset of anhydrobiosis, nematodes like Ditylenchus and Aphelenchoides synthesize large amounts of the disaccharide trehalose. This sugar acts as a powerful "bioprotectant," replacing water molecules around cellular membranes and proteins to prevent them from collapsing or denaturing as the organism dries out. Trehalose forms a glass-like state within the cells, stabilizing the biological structures and allowing the nematode to safely remain in a state of suspended animation until moisture returns.

263. (D) Desiccated aggregates of thousands of Ditylenchus juveniles
"Nematode wool" is a term used to describe the visible, whitish clusters formed by thousands of desiccated Ditylenchus dipsaci juveniles. As the host plant dries out, the nematodes migrate to the surface and aggregate, entering a state of anhydrobiosis together. This communal clustering is thought to reduce the rate of water loss for the individuals within the mass, significantly enhancing their collective survival and ensuring a large population is ready to infect new hosts when moisture returns.

264. (A) The possession of a hollow stomatostylet
A universal morphological characteristic of the Order Tylenchida is the presence of a hollow stomatostylet. This feeding spear is used to puncture plant cell walls and ingest cytoplasm. The stomatostylet is always composed of three parts: the cone, the shaft, and the basal knobs. While the size and shape of the stylet vary among genera and species, its fundamental structure and function as a hollow feeding spear are consistent throughout this large and economically important group.

265. (A) P-2, Q-1, R-4, S-3
These terms describe various aspects of nematode anatomy. Leptoderan refers to a male bursa that does not enclose the tail tip. Holomyarian describes a continuous layer of somatic muscles. Monodelphic signifies a female with a single functional ovary. Tylenchoid refers to a specific esophageal structure with a procorpus, median bulb, isthmus, and basal bulb. Understanding these specialized terms is essential for interpreting taxonomic descriptions and using identification keys to accurately classify different nematode taxa.

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266. (B) That the presence/absence of a gubernaculum is a naturally highly variable taxonomic trait among different nematode groups
In nematode taxonomy, the presence or absence of a gubernaculum is a variable character

that depends on the specific genus or family. While most nematodes possess this sclerotized structure to guide the spicules during mating, it is naturally absent in some groups. The presence, size, and shape of the gubernaculum are important diagnostic features used by taxonomists to distinguish between different taxa, and its absence in a specimen is a significant morphological trait rather than a defect.

267. (A) Secernentea
The presence of phasmids, which are paired sensory organs located in the tail region, is the primary morphological character used to define the Class Secernentea in classical taxonomy. These structures are generally absent in the Class Adenophorea. While modern molecular phylogeny has revised the high-level classification of nematodes, the presence of phasmids remains a highly useful and easily observable diagnostic trait for identifying members of the many diverse families and orders that comprise the Secernentean lineage.

268. (C) Heterodera bodies form rigid cysts retaining eggs
The most significant distinction between these two genera is the formation of a cyst in Heterodera. When the adult female Heterodera dies, her body wall undergoes a tanning process that turns it into a tough, brown, protective sac called a cyst, which retains and protects the eggs. In contrast, Pratylenchus species are migratory endoparasites throughout their lives; they do not become sedentary, nor does the female body undergo any such transformation into a protective cyst after death.

269. (D) Fenestra (vulval or perineal)
A fenestra is a thin, transparent area of the cyst wall in Heterodera and Globodera, typically located in the vulval or anal region. As the juveniles inside the cyst hatch and are ready to emerge, these fenestrae break down or are enzymatically dissolved, providing the primary exit points for the second-stage juveniles (J2) to enter the soil. The shape and number of these fenestrae are important taxonomic characters used to identify and distinguish between various cyst nematode species.

270. (C) Sclerotized knob structures near the vulval cone
Bullae are heavily sclerotized, often dark-colored knob-like structures found internally near the vulval cone of many cyst nematode species, particularly within the genus Heterodera. Their exact function is not fully understood, but they are thought to provide structural support for the vulval area. The presence, size, and arrangement of bullae are critical diagnostic features used by nematologists to distinguish between species when examining the posterior end (vulval cone) of the mature brown cyst.

271. (B) The underbridge
The underbridge is a sclerotized, bridge-like structure located internally across the vulval cone, situated just beneath the vulval bridge in the cysts of some Heterodera species. It provides additional structural support to the posterior region of the cyst. Like bullae and fenestrae, the presence and morphology of the underbridge are essential taxonomic characters used for the precise identification of cyst nematode species, helping researchers distinguish between closely related taxa within this economically important group of plant pests.

272. (D) Exceptionally massive and squarely occupying the body
In the genus Aphelenchoides, the median esophageal bulb (metacorpus) is characteristically large and prominent, often appearing to fill the entire width of the nematode's body in that region. This massive bulb contains a large, crescentic valvular apparatus. This distinctive esophageal morphology, combined with the lack of a bursa in males and the specific location of the dorsal gland orifice, is a defining feature that allows for the rapid identification of these foliar and fungivorous nematodes.

273. (A) Gland orifice location relative to stylet base or bulb
The primary difference between the Orders Tylenchida and Aphelenchida lies in the position of the dorsal esophageal gland orifice. In Tylenchida, the dorsal gland opens into the esophageal lumen near the base of the stylet knobs. In contrast, in Aphelenchida, the dorsal gland empties into the lumen within the median bulb, just anterior to the valve. This fundamental anatomical difference is a key character used to

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separate these two major groups of stylet-bearing nematodes in all taxonomic keys.

274. (C) Facultative meiotic parthenogenesis
Aphelenchoides besseyi, the causal agent of rice white tip disease, frequently utilizes facultative meiotic parthenogenesis. This means that while it is capable of sexual reproduction (amphimixis) when males are present, it can also reproduce asexually through parthenogenesis if mates are scarce. This flexible reproductive strategy allows the nematode to maintain genetic diversity through occasional mating while still being able to rapidly build up damaging populations in a wide range of hosts and environmental conditions.

275. (B) II and III
Statements II and III are correct as Xiphinema species are indeed among the largest root parasites, and many dorylaimids are free-living omnivores or predators. Statement I is incorrect because Trichodorids (stubby-root nematodes) are ectoparasites that feed primarily on the epidermis and outer cortex of root tips; they do not typically penetrate deep into the vascular cylinder. Their feeding damage is concentrated on the root surface, leading to the characteristic "stubby" appearance of the roots.

276. (A) Bursaphelenchus cocophilus
Red ring disease of coconut and other palms is caused by the nematode Bursaphelenchus cocophilus. This nematode is a major pest in the Caribbean and Central and South America. It infests the stem and leaf tissues of the palms, leading to a characteristic red-colored band in the trunk and eventually causing the death of the tree. Like the pine wood nematode, it is transmitted by an insect vector, making it a highly mobile and destructive pathogen.

277. (B) The South American palm weevil (Rhynchophorus palmarum)
The red ring nematode, Bursaphelenchus cocophilus, is primarily transmitted by the South American palm weevil, Rhynchophorus palmarum. The nematodes are carried both internally and externally by the adult weevils. When an infested weevil visits a healthy palm to feed or lay eggs, the nematodes are deposited onto the tree. They then enter the host through wounds, multiply rapidly in the stem tissues, and cause the lethal red ring disease, completing their life cycle within the palm.

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278. (C) A brick-red to brownish band visible in the trunk cross-section
Red ring disease is named for the characteristic symptom seen in a cross-section of an infested palm trunk. A distinct, circular band of brick-red to brownish-colored tissue appears a few centimeters from the trunk's outer edge. This discoloration is caused by the massive presence of nematodes and the host's physiological response to their feeding and migration. This "red ring" is a definitive diagnostic symptom used in the field to identify trees infected by Bursaphelenchus cocophilus.

279. (D) Two-part, bottle-shaped esophagus lacking a valvular bulb
The Order Dorylaimida is morphologically distinguished from the Order Tylenchida by its unique esophageal structure. Dorylaimids possess a "bottle-shaped" esophagus that consists of a slender anterior part and an expanded, muscular posterior section. Crucially, they lack the distinct, muscular median bulb with valvular plates (metacorpus) that is characteristic of the Tylenchids. This fundamental difference in the feeding pump reflects the separate evolutionary lineages and different feeding mechanisms of these two major groups of soil and plant-parasitic nematodes.

280. (A) Xiphinema ectoparasitism with an elongated odontostylet
An important evolutionary difference between these genera is their feeding habit. Xiphinema species are large ectoparasites that use their exceptionally long odontostylet to feed on root tips from the outside, often reaching cells deep within the root. In contrast, Pratylenchus species are migratory endoparasites; they are much smaller and fully enter the root cortex, moving destructively between cells as they feed. These different strategies reflect how these nematodes have adapted to exploit host plant resources while minimizing competition and avoiding plant defenses.

281. (B) Nematode-transmitted polyhedral virus
The term "Nepovirus" is derived from "Nematode-transmitted polyhedral virus." These are a group of plant viruses characterized by their icosahedral (polyhedral) shape and their transmission by

specific soil-dwelling nematodes, primarily those in the genera Xiphinema and Longidorus. Nepoviruses cause many economically important diseases in a wide range of crops, including grapes, berries, and fruit trees. Understanding the specific vector-virus relationship is crucial for developing effective strategies to control the spread of these viral pathogens.

282. (A) Tobacco rattle virus
"Tobravirus" is a name derived from "Tobacco rattle virus," which is the type species for this genus of plant viruses. Tobraviruses are characterized by their rigid, rod-shaped (tubular) particles and are uniquely transmitted by stubby-root nematodes of the family Trichodoridae (genera Trichodorus and Paratrichodorus). These viruses cause significant diseases in many crops, such as corky ringspot in potatoes. The name highlights the historical and scientific importance of tobacco rattle virus in understanding nematode-mediated viral transmission.

283. (A) Particles bind to cuticular linings and are flushed out during feeding
In Xiphinema, plant viruses are transmitted through a non-circulative, semi-persistent mechanism. Virus particles ingested during feeding bind specifically to the cuticular lining of the nematode's esophagus (odontophore and anterior esophagus). When the nematode moves to a new host and initiates feeding, the particles are released from the lining and flushed into the plant cell along with the nematode's saliva. The virus does not enter the nematode's body cavity or replicate within its tissues.

284. (C) No, because the cuticular lining where the virus binds is shed
Virus-transmitting nematodes do not retain the virus after moulting. This is because the virus particles are bound only to the cuticular lining of the esophagus and stoma. During the process of ecdysis, this old cuticular lining is shed along with the outer body cuticle and the stylet. Consequently, the newly moulted nematode is "virus-free" and must feed on an infected plant again to re-acquire the virus particles and become a vector once more.

285. (A) I and III
Statements I and III are correct as Longidorus has a long, hollow odontostylet and its guiding ring is located near the anterior head tip. Statement II is incorrect because Longidorus lacks the massive flanges found at the base of the odontophore in Xiphinema. Statement IV is incorrect because Longidorus species are primarily known vectors for Nepoviruses, not Tobraviruses. These precise morphological and ecological differences are essential for accurately identifying and distinguishing these two major genera of large, ectoparasitic nematodes.

286. (C) A sharp, distinct cuticular projection strictly at the tail terminus
In nematode taxonomy, a "peg" is a small, sharp, and distinct projection of the cuticle found at the absolute tip of the tail. The presence or absence of a tail peg, and its specific shape, are important diagnostic characters used to identify various species, particularly in genera like Meloidogyne or some dorylaimids. This minute structural detail helps taxonomists differentiate between closely related species that may otherwise appear very similar, providing an additional level of morphological resolution for identification.

287. (B) Rotylenchus possesses highly distinct, overlapping esophageal glands that overlap the intestine primarily dorsally
The genus Rotylenchus is distinguished from Helicotylenchus primarily by the morphology of its esophageal glands. In Rotylenchus, the glands are well-developed and form a distinct overlap with the anterior end of the intestine, typically on the dorsal side. In Helicotylenchus, the overlap is usually more variable but often ventrally oriented. This subtle but consistent internal anatomical difference is a key diagnostic character used by experts to correctly classify and identify these common types of spiral nematodes found in soil samples.

288. (D) Dorylaimids have large, pouch-like amphids; Tylenchids have pore-like ones
A fundamental sensory difference between these two major nematode orders lies in their amphidial morphology. Dorylaimids typically possess large, pouch-like or stirrup-shaped amphids with broad, often slit-like external apertures. In contrast, Tylenchid nematodes have much smaller, pore-like amphids that are often difficult to see under a standard light microscope. This difference in amphid structure is a primary character used in taxonomic keys to separate these orders and

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reflects their different evolutionary lineages and sensory adaptations to their environments.

289. (A) A highly posteriorly displaced excretory pore located far down the body near the equatorial region
In many members of the family Tylenchulidae, such as the citrus nematode Tylenchulus semipenetrans, the excretory pore is uniquely and highly displaced toward the posterior end of the body. Instead of being located near the head or nerve ring as in most other nematodes, it is found much further back, sometimes near the equatorial region or even closer to the vulva. This exceptionally posterior position of the excretory pore is a highly diagnostic morphological trait for this specialized family of plant parasites.

290. (C) Taxonomic stability when original type materials are lost
A neotype is an official replacement specimen designated only when the original type material (holotype or syntypes) has been confirmed lost or destroyed. By designating a neotype, researchers provide a new, objective physical standard for a species name. This process is essential for maintaining taxonomic stability, as it ensures that the name remains anchored to a specific biological entity, preventing future confusion and providing a reliable reference for all subsequent research on that particular nematode species.

291. (A) It denotes the distance from the anterior end strictly to the vulva, definitively expressed as a percentage of the total body length
The V-value is a critical and highly stable morphometric character in female nematodes. It represents the distance from the anterior end of the body to the vulva, expressed as a percentage of the total body length. For example, a $V\%$ of 50 indicates the vulva is at the exact mid-point of the body. Because this value is remarkably consistent within a species, it is a primary diagnostic feature used in all identification keys to differentiate between various nematode genera and species.

292. (D) Moisture, temperature, and root exudates from a host
Hatching of root-knot nematode (Meloidogyne) J2 juveniles from the egg is a complex process triggered by several environmental factors. While adequate soil moisture and favorable temperatures are essential, many species are also highly responsive to root exudates—chemical signals released by the roots of a potential host plant. These exudates act as a specific "hatching stimulus," ensuring that the infective J2 juveniles emerge at a time and place where a suitable host is available, maximizing their chances of successful infection.

293. (B) Strictly a heavily hardened exudate originating directly from the hypodermis
The epicuticle is the outermost layer of the nematode cuticle and is formed from secretions produced by the underlying hypodermis. It is not a cellular tissue but a non-living, extracellular matrix. This thin but complex layer is composed of proteins and lipids that provide the primary protective barrier between the nematode and its environment. Its origin from the hypodermal cells is common to all cuticle layers, highlighting the central role of this tissue in the growth and survival of the nematode.

NODIA

294. (C) Intra-uterine hatching where juveniles consume the maternal body
Endotokia matricida is a biological phenomenon where eggs hatch prematurely within the uterus of the female nematode. The resulting juveniles then feed on the mother's internal tissues, eventually leading to her death as they consume her body before emerging to the exterior. This process is often observed in aging females or under conditions of extreme environmental stress. It serves as a desperate reproductive strategy, ensuring that the offspring have a direct source of nutrients to survive when external resources are scarce.

295. (A) I, III, and IV
Statements I, III, and IV are correct. A rachis is a central core in telogonic ovaries, the vagina connects the uterus to the vulva, and hologonic gonads produce germ cells along their entire length. Statement II is incorrect as the spermatheca is a female organ for storing sperm. Statement V is incorrect because parthenogenetic nematodes, which are always female, still possess a fully developed and often complex cuticle, as this structure is essential for their structural integrity and survival regardless of their mode of reproduction.

296. (A) Telogonic proliferation is confined to a distal tip zone
In nematodes, gonads are classified as either telogonic or hologonic based on where the germ cells are produced. In the more common telogonic arrangement, germ cell proliferation is restricted to a small "germinal zone" at the distal tip of the gonad. As cells move away from this zone, they mature into sperm or oocytes. In contrast, in a hologonic gonad (found in whipworms and some others), germ cell division occurs along the entire length of the organ. This distinction is a fundamental anatomical trait.

297. (B) Posterior stoma extension supporting the odontostylet
The odontophore is the posterior part of the dorylaimid feeding spear, which supports the anterior odontostylet. While the odontostylet is the actual piercing tip, the odontophore is the sclerotized extension that connects it to the esophagus. In genera like Xiphinema, the odontophore possesses distinct basal flanges for muscle attachment. Together, the odontostylet and odontophore form the functional feeding spear, and their combined morphology is a primary diagnostic character used in the taxonomy of the Order Dorylaimida.

298. (B) Sluggish earthworm-like contraction using cuticular annules
Ring nematodes (e.g., Criconemoides) exhibit a very distinctive and sluggish mode of movement that is easily recognizable under a stereomicroscope. Unlike the rapid, snake-like undulations of most nematodes, they move by slowly contracting and expanding their bodies in a telescopic, earthworm-like manner. Their deep, backward-projecting cuticular annules provide the necessary traction against soil particles. This slow but steady locomotion is a highly characteristic behavioral trait that allows for the quick preliminary identification of these specialized soil-dwelling ectoparasites.

299. (A) The distinct, projecting vulval cone
The most definitive morphological difference between Globodera and Heterodera is the shape of the posterior end of the mature cyst. Heterodera cysts possess a prominent, protruding vulval cone. In contrast, Globodera cysts are almost perfectly spherical and completely lack this distinct cone-like projection. This simple structural distinction is the first character used in taxonomic keys to separate these two economically important genera of cyst nematodes, providing a reliable and easily observable way to distinguish them in laboratory and field samples.

300. (C) Secretion of effector proteins that manipulate host pathways
Root-knot nematodes are successful polyphagous parasites primarily due to their ability to secrete a complex cocktail of effector proteins from their esophageal glands. These effectors are injected into host cells, where they suppress the plant's immune responses and reprogram host cell development to create specialized giant cells for feeding. This sophisticated molecular manipulation allows the nematode to overcome the diverse defense systems of thousands of different plant species, making them some of the most versatile and destructive parasites in the plant kingdom.

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CHAPTER 03
Nematological Techniques

2016

1. Which spatial pattern is primarily recommended for field sampling of nematodes to ensure representative coverage of the area?
(A) Linear transect sampling
(B) Single-point central sampling
(C) Perimeter boundary sampling
(D) Zig-zag or systemic grid pattern

2012

2. What is the standard recommended soil depth for sampling root-knot nematodes in most annual crops?
(A) 0 to 5 cm
(B) 15 to 30 cm
(C) 50 to 75 cm
(D) 100 to 120 cm

2010

3. Why is it essential to composite multiple soil cores into a single sample during nematode field surveys?
(A) To increase the detection probability of rare and localized nematode species
(B) To account for the patchy and aggregated distribution of soil nematodes
(C) To dilute the concentration of chemical exudates that interfere with extraction
(D) To selectively recover a representative size range of active soil nematodes

2014

4. Identify the INCORRECT statement regarding the handling of soil samples collected for nematode analysis.
(A) Soil samples must be kept sufficiently moist to prevent nematode desiccation.
(B) Sealed plastic bags are preferred to prevent moisture loss during sample transit.
(C) Insulated coolers should be utilized to avoid damage from temperature extremes.
(D) Samples should be kept in direct sunlight to stimulate active nematode hatching.

2017

5. The primary purpose of dividing a field into distinct sub-units or grids before soil sampling is to:
(A) Segregate areas with varying soil types, histories, or topographies
(B) Decrease the total volume of soil required for efficient lab extraction
(C) Ensure that only symptomatic plant tissues are collected from each grid
(D) Increase the overall speed and throughput of the laboratory extraction

2017

6. Which sampling strategy is most appropriate for a declining orchard suspected of nematode infection?
(A) Collecting soil cores exclusively from the base of the primary main trunk
(B) Taking samples only from the inter-row spacing where roots are less dense
(C) Sampling the drip line of both symptomatic and healthy-looking trees
(D) Collecting a single representative core from the exact center of the orchard

2024

7. What happens to plant-parasitic nematodes if soil samples are accidentally frozen before extraction?
(A) Cellular lysis caused by ice crystals results in high mortality.
(B) Metabolic rates increase significantly immediately upon thawing.
(C) They enter a permanent and irreversible cryptobiotic state.
(D) They immediately hatch from egg masses in response to stress.

2009

8. In a composited soil sample, the recommended final volume sent to the laboratory typically ranges between:
(A) 10 to 50 grams of representative soil
(B) 250 to 500 cubic centimeters of soil
(C) 5 to 10 kilograms of bulk field soil
(D) 20 to 25 liters of unprocessed soil

NODIA

2018

9. When sampling for foliar nematodes (Aphelenchoides spp.), the best tissue to collect is:
(A) Fully dried, fallen leaf material found on the soil surface
(B) Fresh leaves exhibiting early interveinal necrotic lesions
(C) Deep taproot systems that lack secondary lateral branching
(D) Healthy and symptomless woody stem tissues from the plant

2008

10. Consider the following statements regarding nematode sampling:
I. Soil moisture at the time of sampling should be near field capacity.
II. Samples should be completely air-dried before shipping to the lab.
III. Rhizosphere soil containing feeder roots yields the highest nematode populations.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2018

11. Which factor least influences the seasonal timing of nematode soil sampling?
(A) Soil temperature
(B) Host plant phenology
(C) Soil moisture levels
(D) Wind direction

2008

12. Removing the top 5 cm of soil before taking a sample core is generally advised because:
(A) Exposure to temperature and desiccation reduces nematode survival.
(B) It contains the highest concentration of plant-parasitic nematodes.
(C) It causes interference during the centrifugal flotation extraction.
(D) It exclusively harbors saprophytic nematodes that mask the parasites.

2001

13. The standard Baermann funnel technique relies primarily on which behavioral characteristic of nematodes?
(A) Active chemotaxis toward specific sugar or nutrient gradients
(B) Active motility through a porous medium into the water
(C) Passive floating based on differences in low specific gravity
(D) Rapid settling through the water column due to high body mass

2003

14. Which modification is most commonly used in the modern Baermann technique to improve aeration and extraction efficiency?
(A) Replacing the standard funnel with a specialized sealed vacuum flask
(B) Using a shallow extraction tray instead of a deep glass funnel
(C) Adding concentrated sodium hypochlorite directly to the water bath
(D) Boiling the water before placing the soil onto the tissue paper

2011

15. The Baermann funnel method is highly inefficient for extracting which group of nematodes?
(A) Sluggish ring nematodes (Criconematidae)
(B) Active root-knot nematode juveniles
(C) Highly motile stunt nematodes
(D) Foliar nematodes from chopped leaves

2004

16. What is the primary function of the tissue paper or muslin cloth used in the Baermann funnel technique?
(A) To absorb toxic root exudates released from the soil
(B) To provide a nutrient source for saprophytic nematodes
(C) To act as a physical barrier while allowing nematode passage
(D) To neutralize the pH of the water used for the extraction

2022

17. Which of the following is a major disadvantage of leaving soil in a Baermann funnel for more than 48-72 hours?
(A) Nematodes will reproduce at a rapid rate, skewing final counts.
(B) The water in the funnel will evaporate completely in this time.
(C) Nematodes will migrate back up into the dry soil of the funnel.
(D) Anaerobic conditions cause nematode mortality and tissue decay.

2008

18. In the modified Baermann tray method, the use of a supporting mesh screen serves to:
(A) Break down and crush large soil aggregates

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manually
(B) Filter out organic debris from the final suspension
(C) Hold the tissue-wrapped soil at the water surface
(D) Electrically repel positively charged soil colloids

2008

19. A sample extracted via the Baermann funnel technique yielded very few active nematodes despite known high field infestation. What is the most likely methodological cause?
(A) The soil was spread too thinly on the tissue surface.
(B) The water level was below the bottom of the soil layer.
(C) The extraction was conducted at an optimal room temperature.
(D) Fresh, highly porous tissue paper was used in the setup.

2019

20. Read the following statements and select the correct option from the choices provided:
Assertion (A): The Baermann funnel technique is widely used for extracting active juveniles of Meloidogyne species from soil.
Reason (R): Meloidogyne juveniles are highly active in water and readily migrate through the tissue paper into the funnel stem.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

21. What adjustment to the Baermann technique is recommended when processing heavy clay soils?
(A) Mixing the soil with coarse sand to improve water movement
(B) Compacting the soil tightly to prevent any water entry
(C) Using boiling water to break apart heavy clay aggregates
(D) Submerging the soil entirely under 10 cm of deep water

2022

22. Which technique utilizes a similar principle to the Baermann funnel but is specifically designed for whole-plant roots in a continuously aerated environment?
(A) Cobb's sieving
(B) Fenwick can
(C) Mist chamber (mistifier) extraction system
(D) Sugar flotation

2015

23. During a Baermann extraction, the addition of a weak solution of hydrogen peroxide to the water is occasionally done to:
(A) Provide supplemental oxygen to prevent anaerobic conditions
(B) Kill all saprophytic nematodes present in the soil sample
(C) Dissolve the filter paper completely during the extraction
(D) Stain the nematodes for easier viewing under the microscope

2023

24. Which condition yields the highest extraction efficiency in a standard Baermann funnel setup?
(A) A thick, dense layer of soil and low temperature (4°C)
(B) A thin layer of soil and high temperature (45°C)
(C) A thick layer of soil and direct sunlight exposure
(D) A thin layer of soil and room temperature (22-25°C)

2023

25. Cobb's decanting and sieving technique separates nematodes from soil particles primarily based on differences in:
(A) Active motility and chemotaxis
(B) Specific gravity and particle size
(C) DNA structure and protein density
(D) Resistance to osmotic pressure

2008

26. In Cobb's sieving method, a 20-mesh (850 µm) or 60-mesh (250 µm) coarse top sieve is primarily used to:
(A) Capture and retain small juvenile nematode stages
(B) Recover and retain the buoyant cysts of Heterodera
(C) Remove root fragments, debris, and coarse pebbles
(D) Extract actively swimming saprophytic soil species

2012

27. Which mesh size is universally recognized for capturing most adult plant-parasitic nematodes in the final stages of Cobb's sieving?

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(A) 10-mesh (2000 µm)
(B) 25-mesh (710 µm)
(C) 100-mesh (150 µm)
(D) 325-mesh (45 µm)

2021

28. What is the fundamental role of the settling time (e.g., 30-60 seconds) in the initial basin during Cobb's decanting process?
(A) Allowing heavy particles to sink while nematodes float
(B) Allowing nematodes to actively swim to the surface
(C) Permitting the nematodes to undergo a molting phase
(D) Facilitating the dissolution of clay colloids

2015

29. A significant advantage of Cobb's decanting and sieving over the Baermann funnel is that it:
(A) Extracts only live, active nematodes
(B) Recovers both sluggish/dead nematodes and highly active ones
(C) Requires significantly less manual labor and equipment
(D) Is completely independent of soil texture

2009

30. Match the standard sieve mesh sizes in List I with their primary capture targets in List II:
List I: Sieve mesh sizes
P. 20-mesh
Q. 100-mesh
R. 325-mesh
S. 500-mesh
List II: Capture targets
1. Small juveniles and finely detailed species
2. Most adult plant-parasitic nematodes
3. Large nematodes (e.g., Xiphinema)
4. Coarse debris and large root fragments
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-2, R-3, S-4

2024

31. During the final sieving step, tilting the sieve at a 45-degree angle under a gentle stream of water helps to:
(A) Wash nematodes off the mesh into a collection beaker
(B) Force nematodes through the mesh into the waste sink
(C) Prevent oxidation of the metal mesh used in the sieve
(D) Kill the nematodes by creating physical trauma to them

2014

32. Which error in Cobb's decanting and sieving technique will result in the greatest loss of nematodes?
(A) Pouring the suspension through the sieves too slowly
(B) Using a gentle spray of water to rinse the sieves
(C) Waiting 10 minutes for the soil suspension to settle
(D) Repeating the suspension and decanting process three times

2009

33. The principle of gravity-based separation in Cobb's technique assumes that nematodes have a specific gravity:
(A) Significantly higher than dense mineral sand and gravel particles
(B) Less than 0.5, ensuring they float on the water surface permanently
(C) Nearly identical to the specific gravity of heavy clay colloids
(D) Greater than 1.0, causing them to settle slower than mineral soil

2013

34. To recover exceptionally long nematodes such as Longidorus or Xiphinema, which sieve should be heavily scrutinized instead of discarded?
(A) 20-mesh
(B) 400-mesh
(C) 60-mesh or 100-mesh
(D) 500-mesh

2021

35. Cobb's sieving is often followed directly by which technique to further purify the nematode suspension from remaining fine soil particles?
(A) Fenwick can extraction
(B) Centrifugal flotation or modified Baermann
(C) Microtomy sectioning
(D) Maceration and blending

2021

36. Which structural feature of a sieve is most critical for accurate nematode recovery?
(A) The overall height of the brass frame
(B) The chemical composition of the outer rim
(C) The color of the binding solder
(D) The precise diagonal aperture size of the wire mesh

NODIA

2022

37. In the centrifugal flotation technique, the extraction relies on altering the specific gravity of the suspension medium. What is the standard specific gravity of the sugar solution used?
(A) 1.00 to 1.05
(B) 1.14 to 1.18
(C) 1.35 to 1.40
(D) 1.50 to 1.60

2012

38. The first centrifugation step in the Jenkins centrifugal flotation method involves spinning the sample in plain water. What is the purpose of this step?
(A) To float the nematodes to the top for collection
(B) To lyse the bacterial cells present in the sample
(C) To pellet soil and nematodes while discarding floating debris
(D) To induce hatching of nematode eggs

2005

39. During the second centrifugation step, a sucrose solution is added. What happens to the nematodes during this spin?
(A) They float because their specific gravity is lower than the solution
(B) They remain in the pellet at the bottom of the tube
(C) They migrate into the tube walls due to electrostatic charge
(D) They disintegrate due to extreme osmotic pressure

2005

40. The following statements relate to the centrifugal flotation technique using sucrose. Read the statements and select the correct option.
I. Prolonged exposure to the sucrose solution can cause severe osmotic distortion of nematodes.
II. The technique is ideal for recovering highly active nematodes but fails for dead ones.
III. It effectively separates nematodes from heavy soil particles.
IV. Silica colloidal gradients (e.g., Ludox) cause more osmotic stress than sucrose.
Which of the above statements are INCORRECT?
(A) I and III
(B) II and IV
(C) I and IV
(D) III and IV

2019

41. Why is it critical to rinse the nematodes on a 500-mesh sieve immediately after they are collected from the sucrose supernatant?
(A) To induce immediate egg laying
(B) To remove sugar and prevent permanent osmotic damage
(C) To kill adhering bacteria and fungi
(D) To selectively filter out male nematodes

2017

42. Silica colloidal solutions (such as Ludox) are sometimes preferred over sucrose in gradient centrifugation because they:
(A) Are significantly cheaper and easier to prepare
(B) Require no centrifugation equipment to function
(C) Induce virtually no osmotic stress on the nematodes
(D) Simultaneously stain the nematodes blue

2013

43. Which type of nematode life stage is uniquely well-recovered by centrifugal flotation compared to the Baermann funnel?
(A) Second-stage juveniles of root-knot nematodes
(B) Adult males of cyst nematodes
(C) Highly motile entomopathogenic infective juveniles
(D) Inactive eggs and sluggish adult stages (e.g., Criconemella)

2009

44. What is the typical centrifugation speed and time used in the sugar flotation method?
(A) 500 rpm for 1 minute
(B) 1750 to 2000 rpm for 4 to 5 minutes
(C) 10,000 rpm for 30 seconds
(D) 25,000 rpm for 15 minutes

2011

45. A technician observed that all nematodes remained in the pellet after the second centrifugation step with sucrose. What is the most likely error?
(A) The centrifuge was operated at too low a temperature.
(B) The specific gravity of the sucrose solution was too low.
(C) The sucrose solution was too concentrated.
(D) The nematodes were already dead before extraction.

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2005

46. Centrifugal flotation is generally considered inappropriate for processing soil with extremely high contents of:
(A) Sand
(B) Fine undecomposed organic matter that floats in sugar
(C) Soluble mineral salts
(D) Gravel and large pebbles

2014

47. When extracting nematode eggs using sodium hypochlorite (NaOCl) and centrifugal flotation, what is the primary role of the NaOCl?
(A) To dissolve the gelatinous matrix holding the eggs
(B) To increase the specific gravity of the flotation medium
(C) To act as a density gradient similar to Ludox
(D) To stain the eggs for easier counting

2021

48. The standard concentration of sucrose used to achieve a specific gravity of 1.18 is approximately:
(A) 100 g per liter of water
(B) 454 g per liter of water (1 lb/liter)
(C) 950 g per liter of water
(D) 2000 g per liter of water

2014

49. The Fenwick can is a specialized extraction device uniquely designed to recover:
(A) Motile juveniles of Meloidogyne
(B) Adult females of Xiphinema
(C) Migratory endoparasites from foliage
(D) Cysts of Heterodera and Globodera

2009

50. Select the correct sequence of events in the Fenwick can extraction method:
(A) Soil drying → Washing over the sloping collar → Floating cysts pass to the overflow → Collection on sieves
(B) Washing wet soil → Centrifugation → Boiling the overflow → Cyst collection
(C) Soil freezing → Adding NaOCl → Overflow collection → Hand-picking cysts
(D) Decanting → Baermann funnel → Fenwick can overflow → Centrifugation

2001

51. Why must soil samples typically be air-dried before extraction in a Fenwick can?
(A) To kill all non-target nematodes
(B) To ensure the cysts fill with air, increasing their buoyancy
(C) To harden the cysts to withstand physical crushing
(D) To facilitate the binding of chemical stains

2019

52. In the Fenwick can apparatus, what is the purpose of the sloping collar?
(A) To catch heavy sand particles before they exit the can
(B) To provide a surface for active nematodes to crawl upon
(C) To mix the soil vigorously without external agitation
(D) To direct upward water flow and cysts into a sieve

2025

53. The mist chamber (mistifier) technique is most highly recommended for extracting which type of nematodes from plant tissue?
(A) Migratory endoparasites from roots
(B) Sedentary endoparasitic adult females
(C) Nematode eggs from soil
(D) Globodera cysts from heavy clay

2023

54. How does the mistifier technique prevent the anaerobic conditions commonly associated with the Baermann funnel?
(A) By utilizing high-speed mechanical aeration blades
(B) By conducting the extraction in a pure oxygen atmosphere
(C) By spraying a fine mist of oxygenated water over samples
(D) By adding hydrogen peroxide continuously to a static water bath

2018

55. During mist extraction, root extracts can release toxic phenolic compounds. How does the mist chamber mitigate this issue?
(A) The flow of water washes away toxic leachates from the vessel
(B) The mist directly neutralizes the pH of phenolic acids
(C) Phenolics are highly volatile and evaporate immediately in the mist
(D) The chamber relies on darkness to prevent phenolic synthesis

2014

56. Which specialized extraction apparatus relies on an elutriation principle (an upward current of water separating particles by settling velocity)?
(A) Fenwick can

NODIA

(B) Seinhorst mistifier
(C) Cobb's decanting basin
(D) Oostenbrink elutriator

2018

57. The primary drawback of the mist chamber technique when dealing with very small or highly fragmented root samples is:
(A) Over-oxygenation causing nematode hyperoxia
(B) Fragments washing into the sample, creating a dirty suspension
(C) Complete dissolution of the root tissue
(D) Immediate sporulation of competing fungi

2022

58. For extracting cysts using the Schuiling centrifuge, what fluid property is heavily manipulated compared to the standard Fenwick can?
(A) Extreme pH
(B) High temperature
(C) Specific gravity using heavy liquids
(D) Magnetic resonance

2016

59. When processing roots in a mist chamber, chopping the roots into 1-2 cm pieces prior to extraction serves to:
(A) Kill the sedentary female nematodes
(B) Prevent the mist from mechanically damaging the roots
(C) Ensure the roots sink to the bottom of the funnel
(D) Increase surface area for water penetration and egress

2002

60. Read the following statements and select the correct option from the choices provided:
Assertion (A): The maceration-blending technique followed by Baermann extraction yields higher numbers of endoparasitic nematodes than simply placing whole roots on a Baermann tray.
Reason (R): Mechanical blending breaks open cortical tissues, physically releasing trapped nematodes and exposing more surface area.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

61. In the incubation method for plant tissue extraction, root samples are placed in a closed container with shallow water. A major limitation of this method is:
(A) Complete destruction of nematode morphological features
(B) High risk of microbial growth and oxygen depletion
(C) Inability to extract active juveniles
(D) Requirement of highly expensive proprietary chemicals

2004

62. Which enzymatic digestion method is utilized to release nematode eggs from the mucilaginous egg masses of Meloidogyne species?
(A) Cellulase treatment
(B) Sodium hypochlorite (NaOCl) agitation
(C) Trypsin digestion
(D) Pectinase immersion

2017

63. When employing the maceration-blending technique for root tissue, the blender should typically be operated for:
(A) 10 to 15 seconds
(B) 2 to 3 minutes
(C) 10 to 15 minutes
(D) 1 hour

2010

64. What is the consequence of blending root tissues for an excessively long time during extraction?
(A) Higher recovery of perfectly intact adult females
(B) Increased specific gravity of the resulting suspension
(C) Mechanical destruction and shearing of the nematodes
(D) Rapid hatching of all internal eggs

2001

65. The addition of a small amount of hydrogen peroxide (H_2O_2) during the incubation of root tissues primarily aids in:
(A) Bleaching the roots for better visibility
(B) Breaking down the cellulose in root cell walls
(C) Forcing the nematodes to enter a dormant state
(D) Suppressing bacteria and supplying oxygen to nematodes

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2001

66. To extract Ditylenchus dipsaci from infected bulbs, the most effective plant tissue technique involves:
(A) Deep freezing the bulb followed by lyophilization
(B) Boiling the bulb in lactophenol for 5 minutes
(C) Chopping bulb scales and placing them in a Baermann funnel
(D) High-speed blending for 5 minutes in a sucrose gradient

2023

67. Which technique is most appropriate for assessing the exact location and feeding site of sedentary endoparasites within host roots?
(A) Maceration-blending
(B) Histopathological microtomy and differential staining
(C) Mist chamber extraction
(D) Cobb's sieving

2006

68. The extraction of Aphelenchoides besseyi from rice seeds typically requires:
(A) Crushing the seeds into fine flour and centrifuging
(B) Applying concentrated sulfuric acid to digest the seed coat
(C) Incubating dry seeds directly on a specialized agar medium
(D) Soaking seeds in warm water to revive anhydrobiotic stages

2004

69. Root incubation in water yields successive catches of nematodes over several days. The nematodes recovered on day 5 were most likely:
(A) Inside the roots and migrated out, or newly hatched from eggs
(B) Located on the root surface originally
(C) Dead prior to the start of incubation
(D) Non-parasitic soil contaminants

2016

70. Match the optical microscopy techniques in List I with their primary functional advantage in nematology in List II:
List I: Microscopy techniques
P. Bright-field microscopy
Q. Phase-contrast microscopy
R. Differential Interference Contrast (DIC)
S. Fluorescence microscopy
List II: Functional advantages
1. Enhances contrast of transparent, unstained internal organs by translating phase shifts
2. Provides a pseudo-3D, shadow-cast image of internal structures with excellent resolution
3. Detects specific tagged molecules or auto-fluorescent structures
4. Standard viewing of stained specimens or opaque structures
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-2, R-1, S-3

2003

71. In optical microscopy, resolving power is mathematically defined by the Abbe equation. Which factor is fundamentally manipulated by using immersion oil to improve resolution?
(A) Numerical aperture (NA) of the objective lens
(B) Wavelength of light (λ)
(C) The focal length of the ocular lens
(D) The mechanical tube length

NODIA

2018

72. Why is Differential Interference Contrast (DIC) or Nomarski microscopy highly preferred over standard bright-field for examining unstained live nematodes?
(A) It permanently fixes the nematode in place.
(B) It uses electron beams instead of light, vastly increasing magnification.
(C) It naturally stains the nematode tissues based on their pH.
(D) It enhances contrast without halos and provides optical sectioning.

2008

73. The primary limitation of using phase-contrast microscopy for viewing thick, mature nematodes is:
(A) The inability to see transparent structures
(B) The "halo effect" which obscures fine boundary details
(C) It requires the specimen to be completely dehydrated
(D) It only operates under ultraviolet light

2017

74. Which component of a compound microscope is responsible for controlling the angle and amount of light illuminating the nematode specimen?
(A) The ocular lens
(B) The fine adjustment knob
(C) The substage condenser and iris diaphragm
(D) The revolving nosepiece

2004

75. A nematologist wishes to observe the precise shape of a nematode's stylet knobs in a completely transparent, unstained specimen. Which optical technique is optimal?
(A) Bright-field with a fully open diaphragm
(B) Low-power dissecting stereomicroscopy
(C) Fluorescence microscopy with a red filter
(D) DIC (Nomarski) microscopy

2021

76. In stereomicroscopy, the image observed by the user is typically:
(A) Three-dimensional and erect (right-side up)
(B) Two-dimensional and inverted
(C) Three-dimensional and inverted
(D) Two-dimensional and erect

2005

77. Parfocality in a standard laboratory microscope means that:
(A) The specimen remains perfectly centered when moving the slide
(B) The specimen remains relatively in focus when switching objectives
(C) The light intensity automatically adjusts when changing objectives
(D) The field of view is identical across all magnifications

2013

78. Which microscopy technique is indispensable for routine picking, transferring, and counting of nematodes in aqueous suspension?
(A) Confocal laser scanning microscopy
(B) Stereomicroscopy (dissecting microscope)
(C) Transmission electron microscopy
(D) DIC microscopy at 1000x magnification

2013

79. The maximum theoretical useful magnification of a standard light microscope using oil immersion is approximately:
(A) 400x
(B) 1000x to 1500x
(C) 10,000x
(D) 100,000x

2019

80. Review the following statements regarding electron microscopy (EM) sample preparation for nematodes:
I. Glutaraldehyde is commonly used as a primary fixative.
II. Osmium tetroxide is applied for post-fixation and lipid contrast.
III. Critical point drying is strictly avoided to prevent cuticle collapse.
IV. Sputter coating with gold or platinum is required for SEM.
V. Ultramicrotomy is essential for TEM but not for SEM.
Which of the above statements is/are correct?
(A) I, II, III and IV
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

2006

81. In Scanning Electron Microscopy (SEM), what is the primary purpose of critical point drying (CPD)?
(A) To rapidly freeze the nematode to preserve internal organelles
(B) To replace water with heavy metals for better electron scattering
(C) To polymerize the epoxy resin used for embedding
(D) To avoid surface tension forces that distort the cuticle

2025

82. Transmission Electron Microscopy (TEM) differs fundamentally from SEM in that TEM:
(A) Scans the outer topography of the nematode to create 3D surface images
(B) Requires living, wet specimens for operation
(C) Passes electrons through thin sections for internal ultrastructure
(D) Employs glass lenses rather than electromagnetic lenses

2014

83. The standard embedding medium used to prepare nematode tissues for ultra-thin sectioning in TEM is:
(A) Paraffin wax
(B) Epoxy resin (e.g., Spurr's or Epon)
(C) Pure glycerol
(D) Sodium silicate

2017

84. During TEM preparation, dehydration of the fixed nematode specimen is typically accomplished using an ascending gradient of:
(A) Sucrose solutions
(B) Formaldehyde
(C) Liquid nitrogen
(D) Ethanol or acetone

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2017

85. What specific feature of nematodes makes their primary fixation for electron microscopy uniquely challenging?
(A) The impermeable nature of their collagenous cuticle
(B) Their lack of a defined nervous system
(C) The rapid degradation of their silica skeleton
(D) Their extreme susceptibility to static electricity

2025

86. How is the impermeability of the nematode cuticle often overcome during fixation for TEM?
(A) By heating the fixative to boiling point
(B) By applying high-voltage electric shocks
(C) By physically cutting the nematode in half while immersed
(D) By dissolving the cuticle with concentrated acid

2011

87. In SEM sample preparation, sputter coating the dried nematode with a thin layer of gold or palladium serves to:
(A) Provide a conductive surface that prevents electron charge build-up
(B) Selectively stain the amphids and phasmids
(C) Kill any remaining living bacteria on the cuticle
(D) Provide structural rigidity to prevent vacuum collapse

2002

88. Which structure would be best studied using Scanning Electron Microscopy (SEM)?
(A) The arrangement of the mitochondrial cristae
(B) The internal lumen of the esophagus
(C) The chromosomal configuration during meiosis
(D) Surface topography of the lip region and amphidial apertures

2002

89. A researcher wants to view the exact cellular structure of the nematode's stylet-secreting glands. Which instrument is required?
(A) Dissecting stereomicroscope
(B) Transmission Electron Microscope (TEM)
(C) Scanning Electron Microscope (SEM)
(D) Phase-contrast compound microscope

2006

90. Arrange the following steps in the correct sequence for calibrating an ocular micrometer:
1. Insert the ocular micrometer into the eyepiece.
2. Place the stage micrometer on the microscope stage and focus.
3. Superimpose the ocular scale over the stage micrometer scale.
4. Align the zero lines of both micrometers.
5. Calculate the true distance represented by one ocular division.
(A) 1, 2, 3, 4, 5
(B) 2, 1, 4, 3, 5
(C) 1, 3, 2, 5, 4
(D) 2, 3, 1, 4, 5

NODIA

2024

91. A camera lucida (drawing tube) attached to a microscope is primarily used in nematology for:
(A) Taking high-resolution digital photographs
(B) Projecting the image onto a large wall screen for teaching
(C) Measuring the precise optical density of the specimen
(D) Superimposing images onto paper for accurate hand-drawing

2024

92. When using an ocular micrometer, the calibration value determined for the 10x objective:
(A) Must be recalculated or adjusted for other objective lenses
(B) Applies universally to all other objectives
(C) Is strictly 1 micrometer per division regardless of the microscope
(D) Is only valid for measuring straight lengths, not curved structures

2015

93. Measuring the curved body of a relaxed nematode using a camera lucida drawing is most accurately done using a:
(A) Straight plastic ruler
(B) Flexible map measurer (opisometer) or digitized software
(C) Standard protractor
(D) Vernier caliper

2008

94. A stage micrometer typically has a total length of 1 mm or 2 mm, subdivided into primary divisions of what size?
(A) 0.1 mm (100 μm) and 0.01 mm (10 μm)
(B) 1 μm and 0.1 μm
(C) 1 cm and 0.1 cm
(D) 1000 μm and 500 μm

2025

95. If 20 ocular divisions perfectly align with 0.3 mm on the stage micrometer, what is the length of one ocular division in micrometers?
(A) 1.5 µm
(B) 15 µm
(C) 30 µm
(D) 150 µm

2016

96. Why must morphometric measurements in nematology ideally be taken from properly killed and fixed specimens rather than live ones?
(A) Live nematodes are optically opaque to bright-field light.
(B) Fixatives naturally enlarge all internal structures uniformly.
(C) Constant movement prevents precise alignment and measurement.
(D) The camera lucida cannot reflect moving objects.

2003

97. Which of the following landmarks is essential for measuring the length of the nematode tail?
(A) From the tip of the head to the base of the esophagus
(B) From the vulva to the anus
(C) From the excretory pore to the tail tip
(D) From the anal opening to the posterior terminus

2010

98. In standard morphometric descriptions, the total body length of a nematode is mathematically denoted by which symbol?
(A) $V\%$
(B) a
(C) L
(D) b

2023

99. De Man's formula relies on ratios to describe nematode morphology because absolute measurements:
(A) Cannot be obtained with optical microscopes
(B) Fluctuate with age/host, while ratios remain more stable
(C) Are legally protected by taxonomy codes
(D) Change permanently when the nematode is placed in water

2021

100. Read the following statements and select the correct option from the choices provided:
Assertion (A): In De Man's formula, the ratio 'V' is always expressed as a percentage rather than a simple fraction.
Reason (R): 'V' represents the distance from the anterior end to the vulva, divided by the total body length, multiplied by 100.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

101. In De Man's morphometric system, the ratio 'a' is calculated by:
(A) Total body length divided by greatest body width
(B) Total body length divided by tail length
(C) Total body length divided by esophageal length
(D) Tail length divided by anal body width

2009

102. A nematode has a total body length (L) of 1000 µm and an esophageal length of 200 µm. What is its 'b' ratio?
(A) 0.2
(B) 2.0
(C) 5.0
(D) 20.0

NODIA

2019

103. The morphometric ratio 'c' describes the proportional length of the:
(A) Tail relative to body length
(B) Esophagus relative to body length
(C) Stylet relative to body width
(D) Vulva to the anus

2002

104. Which parameter is evaluated by the ratio c' (c-prime)?
(A) Total body length divided by tail length
(B) Esophageal length divided by stylet length
(C) Distance from head to excretory pore
(D) Tail length divided by the body width at the anus

2016

105. A female nematode has the vulva located exactly in the middle of its body. Its V% is:
(A) 25%
(B) 50%
(C) 75%
(D) 100%

2010

106. In morphometric reporting, what does the measurement 'm' represent regarding a nematode's stylet?
(A) The maximum width of the stylet knobs
(B) The distance from the stylet base to the dorsal gland orifice (DGO)
(C) The ratio of the length of the conus to total stylet length
(D) The total mass of the stylet

2010

107. The distance from the base of the stylet knobs to the dorsal esophageal gland orifice is commonly expressed as a percentage of the total stylet length. This metric is known as:
(A) a ratio
(B) $V\%$
(C) m ratio
(D) o (or O ratio)

2013

108. Why is heat killing (e.g., in hot water at 60-65°C) considered a critical first step before chemical fixation of nematodes?
(A) It kills the nematode in a relaxed, straight, or natural posture.
(B) It chemically binds the proteins in the cuticle.
(C) It dissolves the internal organs for easier viewing of the body wall.
(D) It immediately evaporates all internal body fluids.

2023

109. What happens if live, active nematodes are dropped directly into a cold chemical fixative like Formalin?
(A) They are preserved perfectly straight.
(B) They undergo severe spasms, becoming contorted and unsuitable.
(C) They instantly lose their coloration but remain relaxed.
(D) They hatch from their eggs prematurely.

2006

110. Match the standard nematode fixatives in List I with their primary chemical components in List II:
List I: Fixatives
P. FA (4:1)
Q. FAA
R. TAF
S. Ditlevsen's fixative
List II: Chemical components
1. Formalin, Acetic acid, Distilled water
2. Formalin, Acetic acid, Ethanol (Alcohol)
3. Triethanolamine, Formalin, Distilled water
4. Formalin, Glacial acetic acid, Glycerin, Distilled water
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2004

111. Which fixative is specifically noted for keeping nematodes relatively soft and preventing the excessive hardening and shrinking often caused by pure formalin?
(A) TAF (Triethanolamine Formalin)
(B) 100% Ethanol
(C) FAA
(D) Glacial acetic acid

2004

112. The FA (4:1) fixative consists of:
(A) 4 parts Formalin and 1 part Acetic acid
(B) 4 parts Alcohol and 1 part Formalin
(C) 10 mL Formalin, 1 mL Glacial acetic acid, and 89 mL water
(D) 40% Formaldehyde and 10% Alcohol

2002

113. When heat-killing nematodes in a small volume of water, what is the most common method to apply the heat?
(A) Placing the counting dish over a direct open Bunsen burner flame
(B) Microwaving the sample on high for 60 seconds
(C) Using a soldering iron directly in the water
(D) Adding boiling water or hot double-strength fixative

2022

114. For long-term preservation of fixed nematodes before clearing, they should ideally be stored in tightly sealed vials containing:
(A) Distilled water at room temperature
(B) Pure 100% ethanol
(C) The same fixative solution used initially
(D) Dry air environment

2005

115. Formalin, the standard biological fixative, is a saturated aqueous solution of formaldehyde gas at approximately what concentration?
(A) 5-10%
(B) 37-40%
(C) 75-80%
(D) 100%

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2006

116. Which chemical in FAA fixative accelerates the penetration of the fixative through the nematode cuticle?
(A) Formaldehyde
(B) Distilled water
(C) Calcium carbonate
(D) Ethanol (Alcohol)

2025

117. What is the primary purpose of clearing nematodes to pure glycerine before permanent mounting?
(A) To match refractive indices, making internal details highly visible
(B) To chemically dissolve the stylet
(C) To permanently stain the reproductive organs red
(D) To increase the overall body length by 10%

2001

118. Seinhorst's rapid method for processing nematodes to glycerine utilizes which highly volatile and toxic solvent to extract moisture?
(A) Chloroform
(B) Benzene
(C) Ethanol
(D) Ether

2011

119. In the glycerol-ethanol method (slow method), nematodes are placed in a dilute solution of glycerine and ethanol, which is then:
(A) Placed in a desiccator to allow slow evaporation
(B) Boiled continuously for 24 hours
(C) Subjected to ultra-centrifugation
(D) Mixed with sodium hypochlorite

2025

120. Review the following statements regarding the processing of nematodes to pure glycerine:
I. Rapid transfer of fixed nematodes directly into pure glycerine causes severe irreversible shrinkage.
II. Seinhorst's slow method prevents osmotic shock by utilizing a gradual evaporation process.
III. Completely dehydrated nematodes in glycerine appear totally black under the microscope.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) II and III
(C) Only III
(D) I and III

2019

121. During the rapid processing of nematodes to glycerine using the Baker method, nematodes are heated in a mixture containing:
(A) Formalin and Ethanol
(B) Lactic acid, Glycerine, and Phenol
(C) Sodium hydroxide and Xylene
(D) Pure Acetone

2024

122. Why must permanent slides mounted in glycerine be thoroughly sealed (e.g., with nail polish or specialized ringing cement)?
(A) Glycerine is highly volatile and will quickly evaporate otherwise.
(B) To prevent light from degrading the glycerine.
(C) To prevent absorption of moisture by hygroscopic glycerine.
(D) To trap oxygen required for preservation.

2016

123. The function of placing glass fiber supports (or glass beads) under the coverslip when mounting nematodes is to:
(A) Provide a background color for contrast
(B) Magnetically align the nematodes in a straight line
(C) Absorb excess glycerine
(D) Prevent nematodes from being crushed by the coverslip

2004

124. The wax-ring method for mounting nematodes involves using a ring of paraffin wax which:
(A) Melts when heated, sealing the coverslip and embedding supports
(B) Stains the nematode cuticle
(C) Chemically reacts with glycerine to form a hard plastic
(D) Dissolves the coverslip edges to bond with the glass slide

NODIA

2016

125. Cobb's aluminum double-coverslip slide was historically designed to allow:
(A) Immersion of the entire slide in liquid nitrogen
(B) Viewing of the nematode specimen from both sides
(C) Culturing of living nematodes inside the slide cavity
(D) Electrical conductivity across the specimen

2025

126. Temporary mounts are typically made in:
(A) Pure anhydrous glycerine
(B) Water or the killing/fixing solution
(C) Canada balsam
(D) Epoxy resin

2015

127. When ringing a permanent glycerine slide with nail polish (Zut or Glyceel), it is critical that:
(A) The coverslip edge is clean and free of excess glycerine
(B) The nail polish mixes freely with the glycerine drop
(C) The slide is kept wet during application
(D) The polish is applied only to the center of the coverslip

2003

128. An advantage of the wax-ring mounting method over liquid ringing cements is that:
(A) It requires no heating equipment.
(B) It centers the nematode automatically.
(C) It acts as both the coverslip support and the primary seal.
(D) It makes the nematode fluoresce under UV light.

2002

129. Which type of support is typically used to match the exact thickness of a large nematode (e.g., Xiphinema) on a slide?
(A) Grains of coarse sand
(B) Pieces of filter paper
(C) Drop of immersion oil
(D) Small pieces of glass rods or spun glass fibers

2022

130. Read the following statements and select the correct option from the choices provided:
Assertion (A): It is essential to use glass fiber supports when mounting nematodes on a slide.
Reason (R): The coverslip exerts pressure that can flatten or crush the nematode body, altering critical diagnostic morphometrics.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

131. The refractive index of pure glycerine used in permanent mounting is approximately:
(A) 1.00
(B) 1.33
(C) 1.47
(D) 1.65

2017

132. What dictates the number and arrangement of nematodes placed in a single drop of glycerine during slide preparation?
(A) They should be clustered randomly in a dense ball.
(B) They must be placed strictly at the outer edges of the drop.
(C) No more than one nematode can ever be mounted per slide.
(D) They should be arranged in a neat row or radially for scanning.

2005

133. The most universally used dye for selectively staining nematodes inside intact plant roots is:
(A) Acid fuchsin
(B) Methylene blue
(C) Safranin
(D) Fast green

2009

134. In the traditional Byrd et al. staining protocol, what is the sequence for clearing and staining roots?
(A) Stain with Acid Fuchsin → Boil in NaOCl → Clear in Glycerine
(B) NaOCl clearing → Rinse → Acid Fuchsin boiling → Destaining
(C) Freeze roots → Stain with Cotton Blue → Boil in water
(D) Acid Fuchsin destain → Lactic acid clearing → NaOCl mounting

2010

135. What is the primary purpose of the sodium hypochlorite (NaOCl) step in root staining methodologies?
(A) To act as a strong bleaching agent to enhance tissue contrast
(B) To stain the nematode cuticle a bright red color
(C) To preserve the roots permanently
(D) To stimulate nematode movement

2002

136. When roots are stained with acid fuchsin, the plant-parasitic nematodes within the tissue typically appear:
(A) Bright green
(B) Black
(C) Transparent

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(D) Deep pink or red

2022

137. Which stain is commonly utilized as an alternative to acid fuchsin, particularly when a blue coloration of the nematodes is preferred?
(A) Janus Green
(B) Cotton blue (Methyl blue)
(C) Eosin Y
(D) Basic fuchsin

2005

138. After boiling roots in the staining solution, they are typically transferred to acidified glycerine. What is the purpose of this destaining step?
(A) To completely wash all stain out of the nematodes
(B) To dissolve the root tissues entirely
(C) To remove background stain while leaving nematodes colored
(D) To harden the roots for microtomy

2017

139. Lactophenol was historically a primary component in root staining solutions; however, its use has significantly declined in modern laboratories due to:
(A) The extreme volatility and fire hazard of the mixture
(B) Its high cost and lack of availability
(C) Its tendency to dissolve the nematode completely
(D) High toxicity and carcinogenic properties of phenol

2014

140. Match the staining components in List I with their function in nematological studies in List II:
List I: Staining components
P. Acid Fuchsin
Q. NaOCl (Sodium hypochlorite)
R. Acidified Glycerine
S. Phloxine B
List II: Functions
1. Destaining the background plant tissue
2. Selectively stains nematode egg masses to facilitate counting
3. Bleaching root tissues before staining
4. Selectively stains nematodes red inside root tissue
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-4, S-3
(D) P-2, Q-1, R-3, S-4

2006

141. Phloxine B (or Food Red 98) is widely applied to root-knot nematode infected roots primarily to:
(A) Highlight the feeding stylet
(B) Stain egg mass gelatinous matrices without staining the roots
(C) Identify dead nematodes from living ones
(D) Bleach the cortical tissue

2001

142. A technician stained a root sample but found that both the roots and the nematodes were uniformly deep red. Which step was most likely omitted or insufficient?
(A) Bleaching with NaOCl
(B) The destaining process in acidified glycerine
(C) Heating during the staining process
(D) The initial water wash

2024

143. Which of the following describes an advantage of the root staining method over the maceration/ blending extraction method?
(A) Observation of nematodes in undisturbed natural feeding sites
(B) Staining provides a precise count of live versus dead nematodes.
(C) Staining yields a much purer suspension of free nematodes.
(D) Staining is significantly faster and requires no chemicals.

NODIA

2010

144. To properly view acid fuchsin stained roots, the most effective equipment to use is a:
(A) Scanning electron microscope
(B) Phase-contrast compound microscope at 1000x
(C) Stereomicroscope with transmitted sub-stage lighting
(D) Fluorescence microscope with a blue filter

2018

145. Histopathological study of nematode-infected roots begins with the fixation of the plant tissue. Which fixative is standardly used for this process?
(A) Pure distilled water
(B) 10% Sodium hypochlorite
(C) Pure Acetone
(D) Formalin-Aceto-Alcohol (FAA)

2018

146. After fixation, histopathological root samples undergo dehydration using an ascending series

taxonomy and diagnostics in plant-parasitic nematodes?
(A) 16S and 23S rRNA
(B) RuBisCO genes
(C) Actin and tubulin genes solely
(D) 18S, ITS (ITS1 and ITS2), and 28S segments

2015

226. What does a "multiplex PCR" reaction accomplish?
(A) Amplification of a single target gene from multiple different soil samples in one tube
(B) Continuous PCR running for more than 100 cycles
(C) Simultaneous amplification of multiple targets in one tube
(D) Combining PCR and RFLP in a single instantaneous step

2013

227. When viewing PCR products on an agarose gel stained with ethidium bromide or a safer alternative, the DNA bands migrate towards the positive electrode because DNA is:
(A) Positively charged
(B) Negatively charged due to its phosphate backbone
(C) Neutrally charged
(D) Highly magnetic

2023

228. Which bioagent is an obligate, endospore-forming bacterial parasite of root-knot nematodes?
(A) Purpureocillium lilacinum
(B) Pochonia chlamosporia
(C) Trichoderma harzianum
(D) Pasteuria penetrans

2012

229. A major constraint in the commercial mass production of Pasteuria penetrans is that it:
(A) Requires in vivo production on living host nematodes
(B) Can only be grown in complete darkness
(C) Readily mutates into a plant pathogen
(D) Evaporates at room temperature

2008

230. The antagonistic fungus Purpureocillium lilacinum (formerly Paecilomyces lilacinus) primarily attacks which stage of the root-knot nematode?
(A) Highly motile infective juveniles in the soil
(B) Adult males
(C) Eggs and sedentary females
(D) Dauer larvae

2023

231. Mass production of nematophagous fungi like Pochonia chlamydosporia using solid-state fermentation is commonly performed on:
(A) Cereal grains and agricultural by-products
(B) Pure quartz sand
(C) Nutrient broth in continuously stirred tanks
(D) Live insects

2012

232. Liquid fermentation for bioagent production is often preferred over solid-state fermentation by industry because:
(A) It eliminates the need for any carbon source.
(B) It results in a completely dry final product straight from the tank.
(C) Fungi produce thicker cell walls in liquid.
(D) It allows better control of environmental parameters for scale-up

2018

233. The infectious structure produced by Pochonia chlamydosporia that allows it to survive adverse soil conditions and formulated effectively is the:
(A) Endospore
(B) Chlamydospore
(C) Conidiophore
(D) Haustorium

2019

234. In solid-state production on grain, what physical parameter is most critical to monitor to prevent the grain from putrefying and to ensure optimal fungal growth?
(A) Light intensity
(B) Carbon dioxide injection rate
(C) Moisture content (typically 30-40%)
(D) Grain color

2008

235. Formulation of biological control agents into a wettable powder (WP) or granules requires the addition of inert carriers. A common carrier material is:
(A) Pure sodium chloride
(B) Concentrated sulfuric acid
(C) Liquid mercury
(D) Talc powder or vermiculite

2023

236. The viability of a mass-produced fungal bioagent is typically assessed by evaluating its:
(A) Colony Forming Units (CFU) per gram of formulated product
(B) Total weight in kilograms
(C) Specific gravity

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specialized feeding cell formation. This damage is typical of:
(A) Migratory endoparasites like Pratylenchus
(B) Sedentary endoparasites like Meloidogyne
(C) Ectoparasites like Xiphinema
(D) Cyst nematodes like Globodera

2024

157. Saprophytic nematodes like Caenorhabditis elegans are routinely cultured in the laboratory primarily because:
(A) They are major agricultural pests.
(B) They serve as excellent genetic and biological model organisms.
(C) They are obligate parasites of soil bacteria.
(D) They produce highly toxic nematicides naturally.

2012

158. The standard agar medium used for culturing Caenorhabditis elegans is:
(A) Potato Dextrose Agar (PDA)
(B) Nematode Growth Medium (NGM)
(C) Murashige and Skoog (MS) medium
(D) Luria-Bertani (LB) agar

2002

159. Which specific organism is most commonly seeded onto NGM plates as the primary food source for C. elegans?
(A) Escherichia coli (strain OP50)
(B) Agrobacterium tumefaciens
(C) Saccharomyces cerevisiae
(D) Fusarium oxysporum

2019

160. Select the correct sequence of steps for initiating a subculture of Caenorhabditis elegans:
(A) Prepare NGM agar → Seed with E. coli OP50 → Incubate overnight → Transfer nematodes using a platinum wire pick
(B) Transfer nematodes → Pour NGM agar → Seed with E. coli → Autoclave the plate
(C) Seed plate with OP50 → Autoclave → Transfer nematodes → Incubate at 37°C
(D) Pick nematodes → Wash in ethanol → Place on dry petri dish → Add liquid NGM

2018

161. Why is the uracil auxotroph strain OP50 of E. coli preferred for culturing C. elegans?
(A) It grows extremely rapidly, engulfing the nematodes.
(B) It naturally fluoresces under bright-field microscopy.
(C) It is completely resistant to all known antibiotics.
(D) It forms a thin lawn allowing easier worm visualization.

2007

162. To create an age-synchronized culture of C. elegans, researchers often use a bleaching solution (alkaline hypochlorite). How does this achieve synchronization?
(A) It chemically induces molting in all juvenile stages at once.
(B) It stops the nematodes from laying any more eggs.
(C) It kills post-embryonic stages while leaving eggs intact.
(D) It selectively kills male nematodes.

2005

163. The optimal temperature range for the standard laboratory culture of C. elegans is:
(A) 4°C to 10°C
(B) 15°C to 25°C
(C) 30°C to 37°C
(D) 40°C to 45°C

2013

164. What is the typical generation time of C. elegans at 20°C from egg to egg-laying adult?
(A) 24 hours
(B) 3 to 4 days
(C) 14 days
(D) 30 days

2011

165. A "dauer" larva in a saprophytic nematode culture is:
(A) A stress-resistant developmental stage formed under starvation
(B) A giant, hyper-reproductive adult female
(C) An unfertilized egg that develops parthenogenetically
(D) A juvenile stage that is highly susceptible to bacterial infection

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2012

166. A critical tool used to physically transfer individual C. elegans worms under a dissecting microscope is a:
(A) Standard micropipette
(B) Fine camel-hair brush
(C) Flattened platinum wire attached to a glass rod (worm pick)
(D) Forceps

of ethanol or tertiary butyl alcohol (TBA). This step is essential to:
(A) Plasmolyze the plant cells
(B) stain the nucleic acids in the giant cells
(C) Remove water to allow infiltration by paraffin wax
(D) Soften the woody secondary xylem

2025

147. In standard microtomy, what embedding medium is typically used to provide structural support to the root tissue during sectioning?
(A) Agarose gel
(B) Paraffin wax
(C) Pure glycerine
(D) Canada balsam

2016

148. A rotary microtome is used to slice paraffin-embedded root tissues into sections. What is the typical thickness of these sections for light microscopy?
(A) 0.5 to 1 μm
(B) 10 to 15 μm
(C) 100 to 200 μm
(D) 1 to 2 mm

2007

149. Differential staining of histopathological sections is performed to distinguish between the nematode, host cell walls, and specialized structures (like giant cells). A common double-stain combination is:
(A) Safranin and Fast Green
(B) Phloxine B and Cotton Blue
(C) Acid Fuchsin and Methylene Blue
(D) Coomassie Blue and Silver Nitrate

2022

150. Review the following statements about histopathological techniques in nematology:
I. Safranin typically stains lignified cell walls and nematode cuticles red.
II. Fast Green typically stains cellulose cell walls and cytoplasm green.
III. Microtome ribbons are floated on warm water to flatten the sections before adhering to the slide.
IV. Deparaffinization using xylene is necessary before aqueous stains can penetrate the section.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II, III and IV

2018

151. Giant cells (syncytia) induced by root-knot nematodes are typically characterized in histological sections by:
(A) Multiple hypertrophied nuclei and dense granular cytoplasm
(B) A single large nucleus and empty vacuole
(C) Complete absence of cytoplasm and nuclei
(D) Formation of heavily lignified woody layers around the nematode

2011

152. The adhesive applied to glass slides to ensure paraffin ribbons do not wash off during the staining process is typically:
(A) Superglue (cyanoacrylate)
(B) Clear nail polish
(C) Paraffin wax
(D) Haupt's adhesive (gelatin/glycerine) or egg albumin

2014

153. What is the role of Xylene in the final stages of preparing a histopathological slide just before mounting with a resinous medium (e.g., DPX)?
(A) It rehydrates the tissue.
(B) It removes ethanol and makes the tissue transparent.
(C) It intensely stains the plant nuclei black.
(D) It dissolves the remaining plant cell walls.

2015

154. Which specialized feeding structure induced by cyst nematodes (Heterodera spp.) is characterized by cell wall dissolution and merging of adjacent protoplasts?
(A) Giant cell
(B) Nurse cell
(C) Syncytium
(D) Gall

2019

155. During histopathology, if sections appear severely torn or fragmented upon cutting, the most likely cause is:
(A) The tissue was infiltrated for too long.
(B) The room temperature is too low.
(C) The plant roots lacked secondary thickening.
(D) The microtome knife is dull or has a nick.

2016

156. A researcher observes localized necrosis and cavities in root cortical tissue without any

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(A) Sedentary endoparasites like Meloidogyne
(B) Cyst nematodes like Heterodera
(C) Foliar nematodes like Aphelenchoides
(D) Migratory endoparasites like Pratylenchus and Ditylenchus

2008

178. What is the fundamental role of Murashige and Skoog (MS) medium in monoxenic nematode culture?
(A) To provide direct nutrition to the nematode
(B) To selectively kill bacterial contaminants
(C) To sustain excised plant roots or callus tissues
(D) To solidify the agar and prevent nematode movement

2017

179. Maintaining absolute sterility during monoxenic subculturing requires all transfers to be conducted:
(A) Under a fume hood
(B) Inside a laminar air flow cabinet using flamed instruments
(C) In a cold room at 4°C
(D) Under complete darkness

2009

180. Match the nematode type in List I with its standard in vitro culture host/substrate in List II:
List I: Nematode types
P. Aphelenchus avenae
Q. Pratylenchus penetrans
R. Caenorhabditis elegans
S. Meloidogyne incognita
List II: Culture hosts/substrates
1. Carrot discs / Excised hairy roots
2. Fungal culture (e.g., Rhizoctonia or Botrytis)
3. Agrobacterium rhizogenes transformed roots (hairy roots)
4. E. coli OP50 lawn
(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-2, Q-3, R-4, S-1

2006

181. Entomopathogenic nematodes (EPNs) of the genera Steinernema and Heterorhabditis are obligate parasites of insects. They are mutually associated with which respective bacterial genera?
(A) Xenorhabdus and Photorhabdus
(B) Bacillus and Pseudomonas
(C) Agrobacterium and Rhizobium
(D) Pasteuria and Pochonia

2003

182. The highly specialized stage of EPNs that survives in the soil and infects the insect host is known as the:
(A) First-stage juvenile (J1)
(B) Adult female
(C) Infective juvenile (IJ), typically a third-stage juvenile
(D) Dauer adult

2008

183. The in vivo method for isolating and culturing EPNs from soil samples most commonly relies on baiting with the larvae of which insect?
(A) Galleria mellonella (Greater wax moth)
(B) Bombyx mori (Silkworm)
(C) Drosophila melanogaster (Fruit fly)
(D) Tribolium castaneum (Flour beetle)

2014

184. What visual symptom is characteristic of a Galleria larva freshly killed by a Heterorhabditis species?
(A) The cadaver turns completely black and putrid.
(B) The cadaver remains its natural pale white color but becomes calcified.
(C) The cadaver dissolves into a watery liquid within 24 hours.
(D) The cadaver becomes brick-red and often exhibits luminescence.

2018

185. The device primarily used for the mass recovery of newly emerged infective juveniles (IJs) from insect cadavers is called a:
(A) Baermann funnel
(B) White trap
(C) Fenwick can
(D) Cobb's decanting basin

2021

186. How does a standard White trap function?
(A) Cadavers are crushed, and the IJs are extracted using a sugar centrifuge.
(B) It uses a vacuum to pull the IJs out of the insect's spiracles.
(C) Cadavers are placed on a moist island; IJs migrate into water.
(D) Cadavers are sprayed with mist, washing the IJs into a collection beaker.

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2004

205. If a test chemical is highly hydrophobic, how is it typically prepared for an aqueous in vitro nematode bioassay?
(A) By dissolving it directly in cold water
(B) Dissolving in a solvent (DMSO/acetone) before adding to water
(C) By vaporizing the chemical over the nematodes
(D) By binding it to heavy metals

2008

206. Hatching inhibition assays for cyst nematodes often require the addition of what specific natural stimulant to serve as a positive control?
(A) Pure glucose solution
(B) Potato root diffusate (PRD)
(C) Sodium chloride
(D) Dilute bleach

2012

207. In a dose-response nematicide assay, what does the term LC50 represent?
(A) The Lethal Concentration required to kill 50% of the population
(B) The Legal Concentration allowed for field application
(C) The Late Crop yield at 50 days
(D) The Live Count of 50 nematodes

2006

208. When screening crop germplasm for host resistance, what is the meaning of "initial inoculum" (P_i)?
(A) The number of nematodes present at the end of the experiment
(B) The percentage of dead plants
(C) The number of nematodes introduced at the start of the trial
(D) The number of galls divided by the root weight

2021

209. The Reproduction Factor (R_f) is a key mathematical formula used to determine host resistance status. It is calculated as:
(A) Final plant weight divided by Initial plant weight
(B) Number of galls divided by total root length
(C) Initial nematode population (P_i) divided by Final nematode population (P_f)
(D) Final nematode population (P_f) divided by Initial nematode population (P_i)

2011

210. An R_f value greater than 1.0 indicates that the tested plant genotype is generally:
(A) Immune
(B) Highly resistant
(C) A susceptible host allowing nematode multiplication
(D) A dead-end trap crop

2007

211. According to standard definitions, a plant that allows high nematode reproduction ($R_f \gg 1$) but suffers virtually no yield loss or damage is termed:
(A) Resistant
(B) Tolerant
(C) Immune
(D) Hypersensitive

2023

212. In the common 0-5 scale for scoring root-knot nematode gall indices, what does a score of 0 typically signify?
(A) Complete root system destruction
(B) 50% of roots galled
(C) No visible galls on the root system
(D) 100% of roots severely galled

2019

213. When screening for resistance to cyst nematodes, what structure is visually counted on the root surface to determine susceptibility?
(A) White or yellow adult females attached to the roots
(B) Egg masses stained with Phloxine B
(C) Syncytia cross-sections
(D) Hypertrophied root tips

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2016

214. Which staining technique is specifically utilized to quantify the number of egg masses in a resistance screening trial for Meloidogyne?
(A) boiling in Acid Fuchsin for 3 minutes
(B) exposure to Osmic acid vapor
(C) Phloxine B immersion for 15-20 minutes
(D) DAPI staining for 1 hour

2006

215. A hypersensitive reaction (HR) is a common mechanism of nematode resistance characterized by:
(A) Rapid, localized death of cells surrounding the invader
(B) The massive proliferation of giant cells to accommodate multiple nematodes
(C) The plant producing a thick waxy cuticle on

same as the field.
(D) The nematodes lost their stylets during transfer.

2014

196. The geometric arrangement of nematode inoculation into a pot is often done by:
(A) Pouring the entire suspension over the foliage
(B) Injecting the suspension directly into the main stem
(C) Painting the suspension onto the cotyledons
(D) Pipetting suspension into small holes near the root zone

2011

197. Which type of experimental layout is most commonly used in greenhouse pot trials to account for spatial environmental variations?
(A) Randomized Block Design (RBD)
(B) Completely Randomized Design (CRD)
(C) Latin Square Design
(D) Split-plot Design

2019

198. The primary purpose of a microplot experiment for estimating crop losses is to:
(A) Grow plants entirely in aeroponic chambers
(B) Use excessively high rates of fertilizers to mask nematode damage
(C) Simulate field conditions while controlling population density
(D) Eliminate all environmental variables by moving the crop indoors

2023

199. A paired-plant design for estimating crop losses in the field relies on:
(A) Comparing adjacent plants with contrasting nematode densities
(B) Comparing a heavily infested field in one country to a nematode-free field in another country
(C) Grafting a susceptible plant onto a resistant rootstock
(D) Growing two different crop species in the same pot

2025

200. Arrange the typical sequence of steps for conducting a nematicide screening trial in a pot bioassay:
1. Fill pots with sterilized potting mixture.
2. Transplant susceptible host seedlings.
3. Standardize and introduce the nematode inoculum.
4. Apply different concentrations of the test nematicide.
5. Harvest plants, assess root damage, and extract final nematode population.

(A) 1, 2, 4, 3, 5
(B) 1, 2, 3, 4, 5
(C) 2, 1, 3, 4, 5
(D) 3, 4, 1, 2, 5

2003

201. The use of a "chemical check" or nematicide trial to estimate crop losses assumes that:
(A) The nematicide directly stimulates plant growth regardless of pests.
(B) Yield differences between treated and untreated plots reflect loss.
(C) The nematicide kills all beneficial fungi in the soil.
(D) Nematodes naturally migrate away from the treated plot into the untreated plot.

2021

202. Which parameter is generally considered the most direct and reliable indicator of root-knot nematode damage severity on a plant?
(A) Leaf surface area
(B) Number of flowers produced
(C) Root gall index (RGI)
(D) Stem thickness

2025

203. In vitro toxicity assays for evaluating potential nematicidal compounds typically measure which two primary parameters?
(A) Stylet length reduction and cuticular shedding
(B) Increase in body width and feeding rate
(C) Gall formation on agar and giant cell size
(D) Mortality percentage and egg hatching inhibition over time

2024

204. During an in vitro mortality assay, how can a researcher physically distinguish between a paralyzed (but living) nematode and a truly dead one?
(A) Touching the nematode with a pick to check for responses
(B) By observing its color; dead nematodes turn fluorescent green.
(C) By boiling the solution; dead nematodes will dissolve.
(D) By freezing the solution; living nematodes will produce ice crystals.

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2013

187. For the in vitro solid culture of EPNs, which substrate is most commonly utilized in flasks or bags?
(A) Sterile sand
(B) Pure potato dextrose agar
(C) Ground insect meal
(D) Polyurethane sponge bits soaked with nutrient medium

2007

188. In liquid in vitro fermentation of EPNs for commercial bio-pesticide production, the bioreactor must first be inoculated with:
(A) The symbiotic bacteria established first
(B) The infective juvenile nematodes only
(C) Host insect tissue extract
(D) A mixture of soil saprophytes to simulate natural conditions

2007

189. A major challenge in scaling up the liquid fermentation of Heterorhabditis species is:
(A) Their inability to reproduce in the dark
(B) Maintaining the primary phase variant of Photorhabdus
(C) The nematodes instantly burrowing into the stainless steel bioreactor walls
(D) Extreme sensitivity to standard oxygen levels

2008

190. Review the following statements regarding experimental designs for proving nematode pathogenicity (Koch's postulates):
I. The nematode must be constantly associated with the disease symptoms in the field.
II. The nematode must be isolated and grown in pure (axenic or monoxenic) culture.
III. The nematode can be substituted by a closely related species during the re-inoculation phase.
IV. Inoculation of the pure culture onto a healthy host must reproduce the original symptoms.
V. The exact same nematode species must be re-isolated from the experimentally infected host.
Which of the above statements is/are INCORRECT?
(A) I and III
(B) Only III
(C) III and IV
(D) II and V

2011

191. When applying Koch's postulates to obligate plant-parasitic nematodes, why is step 2 (isolation in pure culture) technically difficult?
(A) They are obligate biotrophs requiring living plant tissue
(B) They cannot be seen with the naked eye.
(C) They immediately die upon removal from the soil.
(D) They rapidly mutate when isolated.

2005

192. In a pathogenicity experiment, healthy plants are grown in sterile soil. What is the most reliable method for soil sterilization?
(A) Air drying for 48 hours
(B) Application of a mild fungicide
(C) Autoclaving at 121°C and 15 psi and repeating after 24 hours
(D) Freezing at 0°C overnight

2009

193. Why is it essential to include an uninoculated control treatment in a pathogenicity trial?
(A) To provide food for the nematodes if the primary host dies
(B) To measure the natural mutation rate of the plant
(C) To act as a reservoir for nematode reproduction
(D) To confirm symptoms are strictly due to the nematode

2012

194. When preparing a standard nematode inoculum for a pot experiment, the suspension is typically calibrated to contain a specific number of nematodes per milliliter. This relies on counting a representative sample using a:
(A) Haemocytometer
(B) Spectrophotometer
(C) Hawksley slide or Peters' 1 ml counting chamber
(D) Flow cytometer

2008

195. A researcher observes stunting and root galling in a field but fails to reproduce the stunting when the isolated root-knot nematode is inoculated in the greenhouse. What is the most plausible explanation?
(A) Koch's postulates are not applicable to nematodes.
(B) Field stunting was caused by a disease complex absent in the lab.
(C) The greenhouse temperature was exactly the

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its leaves
(D) The plant naturally secreting volatile attractants

2022

216. DNA extraction from a single microscopic nematode for PCR analysis often involves:
(A) Grinding the individual nematode in a mortar with liquid nitrogen
(B) Boiling the individual nematode in a concentrated sulfuric acid bath
(C) Ultracentrifugation of the nematode within a dense sucrose gradient
(D) Incubation in a lysis buffer with Proteinase K and heat inactivation

2007

217. In molecular diagnostics, extracting high-quality total DNA directly from bulk soil samples is often complicated by the presence of:
(A) Excessive oxygen levels
(B) Humic acids and phenolics that inhibit PCR enzymes
(C) Pure silica sand grains
(D) Volatile nematicide residues

2008

218. Which step is specifically designed to remove PCR inhibitors during soil DNA extraction protocols?
(A) Intense mechanical bead-beating
(B) Addition of lysozyme
(C) Purification using spin columns with silica or magnetic beads
(D) Diluting the soil with distilled water 1:1

2015

219. The Polymerase Chain Reaction (PCR) is a molecular tool used primarily to:
(A) Determine the exact specific gravity of a nematode
(B) Translate DNA sequences into proteins
(C) Visualize the nematode ultrastructure
(D) Exponentially amplify a specific target segment of DNA

2017

220. Review the following statements regarding the molecular identification of nematodes:
I. The Internal Transcribed Spacer (ITS) region of ribosomal DNA is highly conserved and shows no variation between species.
II. Species-specific primers are designed to amplify DNA from only one target species, yielding a clear presence/absence band.
III. Restriction Fragment Length Polymorphism (RFLP) relies on enzymes cutting the DNA at specific sequence motifs.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2017

221. In a typical PCR cycle, what happens during the denaturation step at 94-95°C?
(A) Primers anneate to the target sequence
(B) The double-stranded DNA template separates into single strands
(C) Taq polymerase synthesizes the new DNA strand
(D) The DNA is permanently destroyed

2006

222. RFLP (Restriction Fragment Length Polymorphism) analysis distinguishes nematode species by comparing:
(A) The total length of the nematode body
(B) Banding patterns created after digesting DNA with restriction enzymes
(C) The RNA transcription rates of specific genes
(D) The intensity of fluorescence under UV light

2022

223. Real-time PCR (qPCR) offers a massive advantage over conventional PCR in agricultural nematology because it:
(A) Allows for precise quantification of nematode target DNA
(B) Requires no DNA extraction step
(C) Automatically sequences the entire genome
(D) Uses visible light rather than fluorescence

2013

224. DNA barcoding is a standardized approach to species identification using a short genetic sequence. The primary gene region used for barcoding animals, including some nematodes, is:
(A) The gene encoding the green fluorescent protein (GFP)
(B) The entire chloroplast genome
(C) Cytochrome c oxidase subunit I (COI) gene in the mitochondrial DNA
(D) The hemoglobin beta chain gene

2022

225. In addition to COI, which set of ribosomal DNA genes is extensively targeted for molecular

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2019

167. Culturing of free-living nematodes like Panagrellus redivivus is commonly done using which inexpensive substrate?
(A) Moistened oatmeal or wheat germ
(B) Sterile soil
(C) Pure cellulose filter paper
(D) Excised tomato roots

2015

168. Which contamination issue is most detrimental to a C. elegans NGM culture plate?
(A) Accumulation of condensation on the petri dish lid
(B) Slight drying of the agar at the margins
(C) Tracks left by the worms on the agar surface
(D) Fungal growth overgrowing the bacterial lawn

2011

169. Axenic culture of plant-parasitic nematodes refers to:
(A) Rearing nematodes on a host plant in non-sterile field soil
(B) Culturing in the absolute absence of other living organisms
(C) Growing nematodes alongside a single known species of bacteria
(D) Culturing multiple nematode species together for competition studies

2024

170. Read the following statements and select the correct option from the choices provided:
Assertion (A): It is relatively easy to establish axenic cultures of obligate plant-parasitic nematodes on artificial agar media lacking host tissue.
Reason (R): Plant-parasitic nematodes can readily adapt to absorb liquid nutrients directly through their cuticle.
(A) My choice is not listed but: Both A and R are false.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

171. A monoxenic culture in plant nematology is defined as growing a nematode species:
(A) On multiple types of host roots simultaneously
(B) In a completely sterile liquid broth
(C) Using single-sex populations to prevent reproduction
(D) In association with only one other known living organism

NODIA

2003

172. The most successful and widely used technique for the in vitro monoxenic culture of root-lesion nematodes (Pratylenchus spp.) involves:
(A) Carrot discs in sealed petri dishes
(B) Excised root cultures on agar
(C) Pure NGM agar seeded with E. coli
(D) Liquid suspension of homogenized leaf extract

2007

173. What genetically transformed tissue is highly utilized for establishing long-term, vigorous excised root cultures for nematode rearing?
(A) Rhizobium leguminosarum nodules
(B) Agrobacterium rhizogenes-induced "hairy roots"
(C) Agrobacterium tumefaciens crown galls
(D) Bacillus thuringiensis inoculated roots

2012

174. Before inoculating plant-parasitic nematodes onto an in vitro root culture, the nematode inoculum must be:
(A) Placed in an incubator at 40°C for 2 hours
(B) Surface-sterilized to remove contaminating bacteria/fungi
(C) Allowed to dry completely on filter paper
(D) Fed a high-sucrose diet

2001

175. Which chemical combination is frequently used for the surface sterilization of nematode juveniles or eggs prior to in vitro inoculation?
(A) Dilute sodium hypochlorite (NaOCl) and antibiotics
(B) Concentrated hydrochloric acid and ethanol
(C) Pure formaldehyde
(D) Boiling distilled water

2025

176. Radopholus similis, the burrowing nematode, is commonly reared monoxenically in the laboratory on:
(A) Alfalfa callus tissue
(B) bacterial lawns
(C) Carrot discs or excised root explants
(D) Fungal mats of Fusarium

2017

177. Callus culture involves rearing nematodes on an undifferentiated mass of plant cells. Which nematode group feeds exceptionally well on callus tissue?

(D) Refractive index

2025

237. Which of the following defines a "trap crop" strategy in nematode management?
(A) Spraying sticky substances on the soil surface to trap moving nematodes
(B) Destroying a susceptible crop after invasion but before reproduction
(C) Using transgenic plants that secrete nematicides
(D) Planting a crop that physically blocks nematode movement with thick roots

2010

238. In a mass production facility, the initial pure "mother culture" of a bioagent should be regularly tested against target nematodes to confirm that it has not lost its:
(A) Nutritional requirements
(B) Virulence and pathogenicity during repeated subculturing
(C) Resistance to heavy metals
(D) Sensitivity to sunlight

2022

239. The most common sterilization method for the cereal grain substrate before inoculating it with a biocontrol fungus is:
(A) Autoclaving at 121°C and 15 psi
(B) Soaking in 100% bleach for 24 hours
(C) Microwaving for 2 minutes
(D) Freezing at -80°C

2003

240. Review the following statements about host resistance metrics:
I. Resistance solely implies that the plant limits or prevents nematode reproduction.
II. A tolerant plant may support a high reproduction factor ($R_f > 1$) but shows little to no yield suppression.
III. Immunity refers to the complete failure of the nematode to enter or feed on the root, resulting in zero reproduction.
IV. A susceptible plant has a low R_f and high yield loss.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) I and IV
(D) Only IV

2018

241. What characterizes a "nematode-suppressive soil"?
(A) A soil type with such high clay content that nematodes are crushed
(B) A soil recently fumigated with methyl bromide
(C) A highly acidic peat soil (pH 3.0)
(D) A soil exhibiting high levels of indigenous natural enemies

2007

242. During the shelf-life testing of a formulated bio-nematicide, the product must retain a minimum CFU count for typically how long under standard room conditions to be commercially viable?
(A) 24 hours
(B) 1 to 2 weeks
(C) 6 to 12 months
(D) 50 years

2012

243. The attachment of Pasteuria penetrans endospores to the nematode cuticle is highly specific and relies on:
(A) Magnetic attraction
(B) Biochemical receptor-ligand interactions on the cuticle
(C) The nematode physically swallowing the spore
(D) The spore actively swimming toward the nematode using flagella

2006

244. The extraction of active nematodes from large volumes of water (e.g., irrigation water) is typically accomplished by:
(A) Using a standard Baermann funnel directly
(B) Boiling the water and collecting the steam
(C) Adding massive amounts of sugar to float them
(D) Passing the water through ultra-fine sieves to concentrate them

2025

245. When estimating nematode populations, an aliquot is drawn from the final suspension. To ensure accuracy, the suspension must be:
(A) Vigorously agitated to ensure uniform distribution of nematodes
(B) Allowed to settle completely for one hour before drawing the aliquot
(C) Stored at 45°C
(D) Mixed with concentrated acid

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18. (C) To hold the tissue-wrapped soil at the water surface
The supporting mesh screen in the modified Baermann tray method plays a crucial structural role. It holds the tissue-wrapped soil sample suspended just at the surface of the water layer. This placement ensures that the soil remains thoroughly moistened to facilitate nematode exit, while preventing the soil from collapsing into the collection water and clouding the final extract.

19. (B) The water level was below the bottom of the soil layer.
Successful extraction in a Baermann funnel requires continuous, direct contact between the soil sample and the water column. If the water level falls below the bottom of the soil layer, the nematodes cannot migrate into the water. The soil dries out, trapping the organisms within the matrix and resulting in an artificially low recovery rate despite high field infestations.

20. (A) Both A and R are true and R is the correct explanation of A.
The Baermann funnel technique is highly effective for isolating second-stage juveniles of Meloidogyne species from soil samples. These juveniles are active, motile, and readily swim through the porous tissue paper into the water column, settling in the funnel stem. This behavioral characteristic directly explains why this specific methodology yields clean and abundant collections of these target organisms.

21. (A) Mixing the soil with coarse sand to improve water movement
Heavy clay soils possess fine particles that easily compact and restrict water movement, trapping nematodes within the dense soil matrix. Mixing the clay sample with coarse sand before extraction increases overall porosity and improves water circulation. This modification allows nematodes to migrate more freely out of the soil aggregates and pass through the filter during the extraction process.

22. (C) Mist chamber (mistifier) extraction system
The mist chamber extraction system is designed specifically for recovering active nematodes from plant roots and crowns. By continuously spraying a fine mist of water over the tissues in an aerated chamber, the system maintains high moisture levels without depleting oxygen. This prevents the tissue decay and anaerobic suffocation common in static extraction systems like the Baermann funnel.

23. (A) Provide supplemental oxygen to prevent anaerobic conditions
During static Baermann funnel extraction, oxygen levels can quickly deplete, especially in samples with high organic matter. Adding a weak solution of hydrogen peroxide to the water provides a steady source of supplemental dissolved oxygen. This maintains a healthy aerobic environment, preventing nematode suffocation and ensuring they remain active enough to migrate through the filter during extraction.

24. (D) A thin layer of soil and room temperature (22-25°C)
Optimal nematode recovery in a Baermann funnel is achieved using a thin soil layer at standard room temperature. A thin layer minimizes the physical distance nematodes must travel to exit the soil matrix, reducing entrapment. Maintaining temperatures between twenty-two and twenty-five degrees Celsius stimulates nematode activity and movement without causing thermal stress or accelerated mortality.

25. (B) Specific gravity and particle size
Cobb's decanting and sieving technique is a physical separation method for isolating nematodes from soil. It utilizes the differences in specific gravity and particle size between nematodes and mineral soil components. Soil particles settle rapidly in water due to high density, while lighter nematodes remain suspended longer, allowing them to be decanted and collected on fine sieves.

26. (C) Remove root fragments, debris, and coarse pebbles
In Cobb's sieving method, the coarse top sieve acts as a preliminary physical filter. Its large aperture size allows nematodes and fine soil particles to pass through easily while retaining large debris, pebbles, and root fragments. This initial separation prevents the finer diagnostic sieves below from becoming clogged, ensuring efficient recovery of the target organisms.

27. (D) 325-mesh (45 μm)
The three hundred twenty-five mesh sieve is universally accepted for capturing adult plant-parasitic nematodes in Cobb's decanting

NODIA

(D) Concentrated NaOCl

2011

257. An optical microscopy artifact that causes the edges of an unstained nematode to appear glowing and obscure fine details in bright-field or phase-contrast is fundamentally due to:
(A) Excessive magnification
(B) blue filter
(C) camera lucida attachment
(D) Differences in refractive index between nematode and mountant

2015

258. Measuring the length of an extremely coiled nematode using a camera lucida drawing is subject to significant error if:
(A) The opisometer (map measurer) track is traced exactly along the central axis of the nematode body
(B) The drawing is made on standard white paper
(C) Measurements are taken along curves rather than the midline
(D) The 40x objective is used

2003

259. De Man's 'a' ratio relates body length to maximum width. A nematode with an 'a' ratio of 15 is morphologically described as:
(A) Extremely long and filiform (thread-like)
(B) Relatively short and stout in appearance
(C) Lacking a tail
(D) Possessing a massive stylet

2018

260. Review the following statements about mass production of nematode bioagents:
I. Pasteuria penetrans is easily mass-produced in liquid fermentation tanks without host nematodes.
II. Purpureocillium lilacinum can be successfully mass-produced on sterilized rice grains.
III. Pochonia chlamydosporia forms chlamydospores that allow it to survive commercial formulation processes.
IV. Liquid fermentation generally provides better control over pH, aeration, and contamination than solid-state fermentation.
V. The viability of commercial bioagents is measured in Root Gall Indices.
Which of the above statement(s) is/are correct?
(A) II, III and IV
(B) I, II and III
(C) III, IV and V
(D) I, IV and V

2019

261. To verify the pathogenicity of an isolated nematode, Koch's postulates mandate the re-isolation of the pathogen. This proves that:
(A) The introduced nematode caused the observed symptoms
(B) The nematode can survive in dead tissue.
(C) The soil was adequately sterilized.
(D) The plant is fully resistant.

2009

262. In a molecular lab, avoiding contamination from previously amplified DNA (amplicons) when setting up new PCR reactions is managed by:
(A) Autoclaving the Taq polymerase
(B) Boiling all DNA samples for one hour
(C) Using physical separation and aerosol-barrier tips
(D) Conducting PCR in total darkness

2021

263. When using species-specific primers for diagnosing Meloidogyne incognita, the presence of an amplification band of the expected size on an agarose gel indicates:
(A) The DNA of M. incognita is present in the extracted sample.
(B) The sample definitely does not contain M. incognita.
(C) The sample is completely free of any nematodes.
(D) The nematode is resistant to nematicides.

2017

264. A single nematode typically yields very low amounts of total genomic DNA (often < 100 ng). Which technique is highly suited to work with such minute template quantities?
(A) Southern blotting
(B) Phenol-chloroform extraction without amplification
(C) Visual estimation on an agarose gel
(D) Polymerase Chain Reaction (PCR)

NODIA

2004

265. Why are ribosomal DNA (rDNA) arrays highly targeted for nematode molecular diagnostics?
(A) They are singular, single-copy genes.
(B) They exist in repeated tandem copies, increasing PCR success
(C) They encode the proteins forming the stylet.
(D) They are composed of RNA rather than DNA.

2015

246. The standard counting dish used for enumerating nematodes under a stereomicroscope features which internal structural design?
(A) A completely flat, unmarked glass bottom
(B) A deep V-shaped cone
(C) Concentric channels or a gridded matrix to guide scanning
(D) Four completely separate walled quadrants

2007

247. The Hawksley slide, specifically designed for counting standardized volumes of nematode suspensions, has a fixed volume chamber of:
(A) 0.1 ml
(B) 1.0 ml
(C) 10.0 ml
(D) 100 ml

2022

248. A researcher counts an average of 45 nematodes in three 1 ml aliquots from a total extraction suspension volume of 50 ml. The original soil sample weighed 200 g. What is the estimated nematode population per 100 g of soil?
(A) 450
(B) 1125
(C) 2250
(D) 4500

2023

249. When processing samples suspected to contain quarantine regulatory nematodes, the extraction must be conducted in:
(A) Open fields
(B) A certified containment facility with strict waste protocols
(C) A standard unsealed greenhouse
(D) Direct sunlight

2007

250. The recovery of eggs from soil without relying on hatching techniques is exclusively achieved using:
(A) Baermann funnel extraction
(B) Mistifier extraction
(C) Centrifugal flotation with sucrose or magnesium sulfate
(D) Oostenbrink elutriator without secondary purification

2002

251. Which environmental variable most significantly biases the recovery of nematodes from a field soil sample during shipping if not properly managed?
(A) Atmospheric pressure
(B) Darkness
(C) Background noise
(D) Damage caused by extreme high temperatures

2006

252. The term "composite sampling" specifically implies taking:
(A) Multiple cores mixed to form one representative sample
(B) A single deep core per hectare
(C) Soil only from the most severely diseased plant
(D) Roots from multiple distinct crop species

2018

253. Why are deep-rooted perennial crops often sampled at multiple depths (e.g., 0-30 cm and 30-60 cm)?
(A) Nematodes naturally migrate deeper during the night.
(B) Populations stratify based on root and moisture profiles
(C) It is legally mandated for all crops.
(D) Shallow sampling cannot extract large nematodes.

2005

254. The extraction efficiency of the centrifugal flotation technique for clay soils is often lower than for sandy soils because:
(A) Clay particles are lighter than nematodes and float in sugar.
(B) Clay aggregation traps nematodes in the heavy pellet
(C) Clay instantly crystallizes the sucrose.
(D) Nematodes naturally dissolve in clay.

2019

255. A technician mistakenly uses a 20-mesh sieve as the final collection sieve in Cobb's decanting method. What is the expected outcome?
(A) Nearly zero nematode recovery due to large apertures
(B) A perfectly clean sample containing all adult nematodes
(C) A sample consisting entirely of nematode eggs
(D) The sample will burst the sieve mesh

2004

256. For fixing soft-bodied marine or estuarine nematodes, the fixative is often prepared using:
(A) Pure distilled water
(B) 100% Glycerine
(C) Filtered seawater to prevent osmotic explosion

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(A) The periodic table
(B) The FAO crop yield database
(C) The meteorological archive
(D) NCBI GenBank or BOLD systems

2001

277. Formulated bio-nematicides are often sensitive to abiotic environmental factors when applied in the field. Which factor is universally recognized as highly detrimental to fungal bioagent spores like P. lilacinum?
(A) Intense ultraviolet radiation from direct sunlight
(B) Moderate soil moisture
(C) High organic matter in the soil
(D) Presence of earthworms

2022

278. Nematodes are technically classified based on their body cavity as:
(A) Acoelomates
(B) Eucoelomates
(C) Pseudocoelomates
(D) Hemicoelomates

2010

279. The Baermann funnel is heavily biased toward recovering active nematodes. If a population count of total nematodes (dead and alive) is strictly required for an ecological study, the best extraction method to pair with it is:
(A) Centrifugal flotation with sucrose
(B) Direct visual examination of raw soil
(C) Placing soil directly into boiling water
(D) Standard mist chamber extraction

2024

280. Cobb's sieving basins are uniquely designed with a sloping side to:
(A) Increase the water pressure
(B) Prevent the basin from rusting
(C) Ensure the basin fits under standard lab taps
(D) Allow heavy particles to slide into the bottom

2018

281. The primary morphological feature differentiating a second-stage juvenile (J2) of Meloidogyne from a free-living bacterivorous nematode during extraction is the presence of a:
(A) Segmented body
(B) Stoma modified into a protrusible hollow stylet
(C) Pair of compound eyes
(D) Highly developed set of legs

2006

282. Using the Fenwick can, the floating debris and cysts that wash over the collar are typically caught on a standard sieve of what mesh size?
(A) 10-mesh (2 mm)
(B) 400-mesh (38 µm)
(C) 60-mesh (250 µm)
(D) 1000-mesh (10 µm)

NODIA

2001

283. During histopathology, replacing ethanol with a clearing agent like xylene or histoclear is crucial because:
(A) Ethanol reacts explosively with paraffin wax.
(B) Xylene naturally hardens the plant cell walls.
(C) Xylene stains the nematode nuclei blue.
(D) Ethanol is immiscible with the non-polar paraffin wax

2018

284. In phase-contrast microscopy, the phase plate in the objective lens works in conjunction with which corresponding component in the condenser?
(A) The annular diaphragm (phase annulus)
(B) The immersion oil drop
(C) The blue daylight filter
(D) The polarizing prism

2022

285. A standard biological electron microscope (TEM) operates under a high vacuum. If a nematode specimen is placed inside without complete dehydration:
(A) It will become perfectly preserved.
(B) The residual water will boil and destroy the ultrastructure.
(C) The water will solidify into a protective ice block.
(D) The electrons will pass through the water faster, improving image quality.

2013

286. When identifying an unknown nematode, accurate morphometric ratios $(a, b, c, V\%)$ combined with morphological features constitute classical:
(A) molecular phylogenetics
(B) Alpha taxonomy (morphological taxonomy)
(C) Ecological modeling
(D) Histopathology

2009

287. Which chemical must be handled with extreme caution in a fume hood due to its strong pungent odor and high toxicity when preparing TAF fixative?
(A) Formalin (formaldehyde)
(B) Distilled water
(C) Triethanolamine
(D) Ethanol

2019

288. An advantage of the wax-ring mounting technique is that the paraffin wax:
(A) Acts as an adhesive binding the nematode to the glass
(B) Is highly transparent to electron beams
(C) Can be easily reheated to remelt and reposition
(D) Dissolves the stylet for clearer internal viewing

2025

289. When preparing Acid Fuchsin stain for roots, glacial acetic acid is added to the solution to:
(A) Provide a carbon source for the nematodes
(B) Bleach the dark pigments of the root
(C) Solidify the stain into a gel
(D) Lower the pH to enhance dye binding to proteins

2017

290. What specific advantage does the monoxenic culture of plant-parasitic nematodes on excised roots offer over standard pot cultures in the greenhouse?
(A) It perfectly mimics the complex multi-species soil microbiome.
(B) It eliminates the need for expensive laboratory equipment.
(C) It allows year-round production of pure inoculum
(D) It naturally induces resistance in the root tissue.

2013

291. White traps are highly effective for extracting EPN infective juveniles because they leverage the nematodes' natural instinct to:
(A) Feed on filter paper
(B) Migrate from cadavers to moist environments for new hosts
(C) Burrow deep into dry soil
(D) Form resting cysts on dry surfaces

2023

292. In a replicated greenhouse pot experiment to evaluate host resistance, standardizing the pot size, soil volume, and environmental conditions ensures that:
(A) All plant varieties will yield exactly the same.
(B) Nematodes will reproduce at identical rates across all pots.
(C) No chemical nematicides are needed.
(D) Observed reproduction differences are due to host genetics

2021

293. The extraction of extremely active migratory endoparasites like Radopholus similis from chopped banana roots is best achieved with highest yield using:
(A) Prolonged mist chamber extraction (mistifier)
(B) Direct visual observation of intact roots
(C) The Fenwick can
(D) Boiling the roots in NaOCl

2005

294. In an agar-based nematicide bioassay, a compound that prevents nematodes from moving but from which they fully recover once transferred to clean water is classified as:
(A) A true nematicide
(B) A bio-stimulant
(C) A nematostat
(D) A fumigant

2007

295. Which DNA extraction reagent acts to physically disrupt cell membranes and denature proteins, releasing the nucleic acids?
(A) A lysis buffer containing SDS and Proteinase K
(B) Pure water
(C) 100% Ethanol
(D) Agarose

2010

296. A major benefit of using DNA barcoding for regulatory and quarantine nematode detection is:
(A) It requires no scientific equipment.
(B) It automatically kills all nematodes in the shipment.
(C) It replaces the need for field sampling entirely.
(D) Identification is possible from eggs, juveniles, or males

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2025

297. The commercial viability of Purpureocillium lilacinum formulations largely depends on the production of a high concentration of resilient:
(A) Mycelial fragments
(B) Conidia (spores)
(C) Endospores
(D) Nematode-trapping rings

2015

298. Pasteuria penetrans reduces root-knot nematode populations in the field through two main mechanisms: obligate parasitism of the female, and:
(A) Releasing volatile fumigants into the soil
(B) Secreting enzymes that dissolve the plant roots
(C) Impeding infective juvenile motility via spore coating
(D) Outcompeting the nematode for bacterial food

NODIA

2001

299. In experimental pot trials to determine crop loss, "inoculum pressure" refers to:
(A) The physical compaction of the soil
(B) The atmospheric pressure in the greenhouse
(C) The weight of the water applied during irrigation
(D) The initial density of nematodes introduced per unit

2005

300. The ultimate objective of systematically standardizing all sampling, extraction, morphometric, and molecular protocols in diagnostic nematology is to:
(A) Ensure accurate, reproducible identification/quantification
(B) Increase the overall cost of diagnostic services
(C) Eliminate the need for professional taxonomists
(D) Prove that all nematodes are harmful parasites

****

ANSWERS

1. (D) Zig-zag or systemic grid pattern
Field sampling of nematodes requires a representative spatial pattern because of their highly aggregated and patchy distribution in soil. A zig-zag or systematic grid pattern ensures thorough coverage across the entire field area. This method increases the probability of intersecting localized populations, thereby providing a more reliable estimate of the actual nematode population density present in the soil.

2. (B) 15 to 30 cm
Root-knot nematodes primarily infect the active root zone where feeder roots are most abundant. For most annual crops, the bulk of this root system and the highest concentration of nematodes occur within the top fifteen to thirty centimeters of soil. Sampling at this depth ensures recovery of representative populations while avoiding desiccated upper layers and unproductive deeper profiles.

3. (B) To account for the patchy and aggregated distribution of soil nematodes
Nematodes are not distributed uniformly throughout agricultural fields but instead occur in highly aggregated, patchy clusters. Collecting and compositing multiple soil cores into a single representative sample minimizes the spatial variation inherent in these field populations. This process provides a more accurate and average estimate of the overall nematode density within the designated management unit.

4. (D) Samples should be kept in direct sunlight to stimulate active nematode hatching.
Nematodes are extremely sensitive to temperature extremes and rapid desiccation. Exposing collected soil samples to direct sunlight raises internal temperatures within transit bags, leading to rapid mortality and biological degradation of the specimens. Proper handling requires keeping samples cool, moist, and shaded in insulated containers to preserve the viability and structural integrity of the nematodes prior to extraction.

5. (A) Segregate areas with varying soil types, histories, or topographies
Field division into distinct management zones or grids is essential because nematode distribution is strongly influenced by environmental and management factors. Segregating areas based on soil texture, crop history, or topography allows for targeted sampling of relatively homogeneous units. This stratified approach prevents the dilution of high nematode populations and yields precise diagnostic data for localized field sections.

6. (C) Sampling the drip line of both symptomatic and healthy-looking trees
In declining orchards, active feeder roots are concentrated primarily along the drip line of the tree canopy. Sampling this specific zone of both symptomatic and healthy-looking trees provides a clear comparison of nematode densities associated with damage. This strategic approach ensures collection from areas where plant-parasitic nematodes are actively feeding, reproducing, and driving orchard decline.

7. (A) Cellular lysis caused by ice crystals results in high mortality.
Accidental freezing of soil samples before extraction leads to the formation of internal ice crystals within nematode bodies. This physical crystallization causes immediate cellular lysis and irreversible damage to their delicate anatomical structures. Because most standard extraction methods require live, active nematodes, freezing severely compromises the sample, resulting in extremely low and inaccurate recovery rates in the laboratory.

8. (B) 250 to 500 cubic centimeters of soil
Diagnostic laboratories require a standardized volume of soil to yield statistically reliable and representative nematode counts. A final volume of two hundred fifty to five hundred cubic centimeters provides an optimal balance between sample representativeness and processing efficiency. This quantity ensures sufficient material for accurate extraction procedures without overwhelming the capacity of laboratory equipment during analysis.

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9. (B) Fresh leaves exhibiting early interveinal necrotic lesions
Foliar nematodes actively inhabit and migrate through the aerial parts of host plants, particularly leaves. Collecting fresh leaves that exhibit early, characteristic interveinal necrotic lesions ensures a high recovery of active nematodes from the symptomatic tissues. This targeted sampling captures the pest population while they are actively feeding and reproducing inside the leaf mesophyll layers.

10. (B) I and III
Successful nematode extraction depends heavily on the physiological state of the organisms and their association with host tissues. Soil moisture near field capacity keeps nematodes active and facilitates their movement, while rhizosphere soil contains active feeder roots that support maximum population densities. Conversely, air-drying samples is highly detrimental as it causes rapid desiccation and widespread mortality.

11. (D) Wind direction
The seasonal dynamics of soil nematode populations are governed by biological and environmental factors such as soil temperature, moisture levels, and host plant growth stages. These variables directly dictate nematode reproduction, survival, and vertical migration within the soil profile. Wind direction has no biological or physical influence on these subterranean populations, making it irrelevant to sampling schedules.

12. (A) Exposure to temperature and desiccation reduces nematode survival.
The uppermost five centimeters of agricultural soil are constantly subjected to extreme fluctuations in temperature, intense solar radiation, and rapid desiccation. These harsh environmental conditions significantly reduce the survival and density of plant-parasitic nematodes in this layer. Discarding this top layer prevents the collection of unrepresentative, degraded samples and focuses on the populated root zones.

13. (B) Active motility through a porous medium into the water
The Baermann funnel extraction method is designed to isolate active nematodes from soil or plant tissue. It operates on the biological principle that motile nematodes will actively migrate out of the sample, pass through a porous tissue barrier, and sink through the water column. Sluggish, dead, or sedentary stages cannot perform this migration and remain unrecovered.

14. (B) Using a shallow extraction tray instead of a deep glass funnel
Modern adaptations of the Baermann technique replace the traditional deep funnel with shallow extraction trays to improve overall efficiency. Shallow trays significantly increase the surface area of the sample while reducing the depth of the water column. This configuration enhances oxygen availability throughout the extraction medium, preventing anaerobic conditions that otherwise cause nematode mortality during prolonged processing.

15. (A) Sluggish ring nematodes (Criconematidae)
Sluggish nematodes, such as members of the family Criconematidae, possess slow movement patterns and heavy cuticular ring structures. Because the Baermann funnel technique relies entirely on rapid, active migration through a paper barrier, these slow-moving organisms are unable to pass into the water column. Consequently, this extraction method yields extremely poor recovery rates for such inactive species.

16. (C) To act as a physical barrier while allowing nematode passage
In the Baermann funnel setup, the tissue paper or muslin cloth serves as a critical semi-permeable filter. It physically retains soil particles, organic debris, and silty suspensions, keeping the final water collect clear for microscopic examination. Concurrently, its porous structure allows active, motile nematodes to swim freely through the barrier and settle at the bottom of the apparatus.

17. (D) Anaerobic conditions cause nematode mortality and tissue decay.
Prolonged incubation of soil in a static Baermann funnel beyond forty-eight to seventy-two hours leads to severe oxygen depletion. The accumulation of soil microorganisms and decomposing organic matter rapidly consumes available oxygen, creating toxic anaerobic conditions. This environment causes high mortality among the extracted nematodes, leading to their rapid tissue decay and rendering them unidentifiable under microscopy.

NODIA

2003

266. A microtome section of a nematode-infected root stained with Safranin and Fast Green shows the nematode stained bright red against green cortical cells. This indicates the nematode cuticle has an affinity for:
(A) acidic dyes that bind to pure cellulose
(B) Phloxine B
(C) Basic dyes binding to acidic or lignified components
(D) Osmium tetroxide

2009

267. When fixing plant roots for histopathology, the roots should ideally be cut into pieces no longer than 5-10 mm. This is strictly to:
(A) Ensure the nematode is cut in half
(B) Fit them on a standard 3x1 inch microscope slide
(C) Stop the roots from photosynthesizing
(D) Allow uniform and rapid fixative/medium penetration

2004

268. The primary nutritional mode of Caenorhabditis elegans in its natural habitat and in laboratory NGM culture is:
(A) Bacterivory (feeding on bacteria)
(B) Herbivory (feeding on root hairs)
(C) Predation (feeding on other nematodes)
(D) Omnivory

2005

269. A monoxenic carrot disc culture of Radopholus similis shows massive fungal contamination after two weeks. The most probable point of failure was:
(A) The carrot discs were too thick.
(B) Inadequate surface-sterilization of the nematode inoculum
(C) The incubation temperature was too low.
(D) The culture was kept in darkness.

2001

270. Entomopathogenic nematodes kill their insect hosts extremely quickly (often within 48 hours) compared to standard plant parasites. This rapid mortality is due directly to:
(A) Massive physical consumption of the insect brain by the nematode
(B) Release of virulent, toxin-producing symbiotic bacteria
(C) The nematode draining the insect's blood
(D) The nematode blocking the insect's spiracles, causing suffocation

2015

271. When estimating crop loss in the field, a key assumption of using a nematicide paired-plot design is that the nematicide applied:
(A) Targets nematodes without stimulating direct plant growth
(B) Has significant phytotoxic effects on the crop
(C) Provides complete, 100% eradication of all soil organisms
(D) Alters the genetic resistance of the plant

2017

272. In an in vitro hatching assay for root-knot nematodes, the standard control treatment involves placing egg masses in:
(A) Pure nematicide
(B) 100% ethanol
(C) Distilled or tap water
(D) Formalin

2011

273. The primary metric used to evaluate a plant variety's tolerance (as opposed to resistance) to nematode infection is:
(A) The absolute number of eggs produced per root
(B) The chemical composition of the root exudates
(C) The thickness of the leaf cuticle
(D) Comparative yield of infected vs. uninfected plants

2007

274. In a screening trial, a tomato variety inoculated with 5000 Meloidogyne incognita eggs (P_i) yields a final population (P_f) of 50,000 eggs. What is the R_f, and what is the resistance status?
(A) $R_f = 0.1$; Highly Resistant
(B) $R_f = 45{,}000$; Immune
(C) $R_f = 10$; Susceptible
(D) $R_f = 1.0$; Tolerant

2025

275. Real-time PCR utilizes fluorescent dyes or probes. The cycle at which the fluorescence signal crosses a defined threshold level is known as the:
(A) Melting temperature (T_m)
(B) Cycle threshold (C_t or C_q)

2002

276. In DNA barcoding using the COI gene, unknown species are identified by comparing their amplified sequence against a comprehensive database, such as:

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method. With a precise aperture size of forty-five micrometers, this fine mesh allows water and silty clay particles to wash through while physically retaining most adult nematodes. This ensures a concentrated and relatively clean suspension of target organisms for analysis.

28. (A) Allowing heavy particles to sink while nematodes float
The brief settling time in Cobb's decanting process is critical for gravity-based separation. Heavy mineral particles, such as sand and gravel, sink rapidly to the bottom of the basin within thirty to sixty seconds. Plant-parasitic nematodes, possessing a lower density, remain suspended in the water column and can be cleanly decanted onto the collection sieves.

29. (B) Recovers both sluggish/dead nematodes and highly active ones
Unlike the Baermann funnel, which depends entirely on active nematode motility, Cobb's decanting and sieving technique is a mechanical separation process. It successfully recovers both highly active and sluggish, injured, or dead nematodes from soil samples. This makes the method indispensable for ecological studies and total population counts where non-motile individuals must be accounted for.

30. (A) P-4, Q-3, R-2, S-1
Standard sieve mesh sizes are calibrated to target specific fractions of soil suspensions. The coarse twenty-mesh sieve retains large debris, whereas the intermediate hundred-mesh sieve captures large-bodied species. Most adult plant-parasitic nematodes are recovered on the three hundred twenty-five mesh, while the ultra-fine five hundred-mesh sieve is necessary to capture small juveniles and microscopic species.

31. (A) Wash nematodes off the mesh into a collection beaker
Tilting the sieve at a forty-five-degree angle during the final rinse is a practical technique to maximize nematode recovery. A gentle stream of water directed across the tilted mesh washes the retained nematodes down to the lower edge, collecting them efficiently. This prevents the specimens from sticking to the wire mesh or being lost during transfer.

32. (C) Waiting 10 minutes for the soil suspension to settle
Allowing the soil suspension to settle for ten minutes before decanting results in a severe loss of nematodes. While heavy sand settles quickly, nematodes will also sink to the bottom of the basin during such an extended period. Decanting after ten minutes leaves the majority of the nematode population trapped in the discarded bottom sediment layer.

33. (D) Greater than 1.0, causing them to settle slower than mineral soil
Gravity-based separation in Cobb's method relies on the physics of sedimentation in water. Nematodes have a specific gravity slightly greater than one, which is much lower than that of mineral soil particles like sand. This difference causes nematodes to settle far more slowly than soil minerals, keeping them suspended in the water column for clean decanting.

34. (C) 60-mesh or 100-mesh
Long-bodied nematodes, such as species of Longidorus or Xiphinema, have physical dimensions that exceed those of standard plant pathogens. Due to their large size, these organisms are often retained on coarser sieves, such as the sixty-mesh or hundred-mesh, during processing. Discarding these screens without careful examination can lead to a total loss of these target genera.

35. (B) Centrifugal flotation or modified Baermann
Cobb's decanting and sieving technique successfully isolates nematodes but often leaves fine silt and organic debris in the final suspension. Following this method with centrifugal flotation or a modified Baermann tray further purifies the sample. This secondary processing removes remaining particulate matter, yielding a clean, debris-free suspension that is easy to analyze under a microscope.

36. (D) The precise diagonal aperture size of the wire mesh
The accuracy of nematode recovery during sieving is determined by the precise diagonal aperture size of the wire mesh. If the aperture dimensions vary or are damaged, target nematodes can easily pass through the screen and be lost in the waste. Consistent, high-quality manufacturing of these openings is essential for reproducible quantitative analysis in diagnostic laboratories.

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37. (B) 1.14 to 1.18
Centrifugal flotation relies on a density gradient where the flotation medium matches or exceeds the buoyancy threshold of the target organisms. A sucrose solution calibrated to a specific gravity between 1.14 and 1.18 is ideal. This density allows nematodes to float to the surface while heavier soil components pellet at the bottom of the centrifuge tube.

38. (C) To pellet soil and nematodes while discarding floating debris
The initial centrifugation step in plain water serves to concentrate the sample by pelleting all heavy soil particles along with the nematodes. Buoyant organic matter, such as root fragments and decayed plant tissue, remains in the supernatant and is discarded. This step prepares a concentrated pellet, simplifying the subsequent sugar flotation and purification process.

39. (A) They float because their specific gravity is lower than the solution
In the second centrifugation step, the addition of a dense sucrose solution alters the buoyancy of the suspended particles. Because plant-parasitic nematodes have a lower specific gravity than the 1.18 sucrose medium, they float upward during spinning. They collect in the supernatant layer at the top of the tube, separating from the heavier soil minerals.

40. (B) II and IV
The centrifugal flotation method using sucrose is highly effective for recovering both live and dead nematodes because it is purely physical. It successfully separates specimens from heavy soil minerals based on density. However, silica colloidal gradients like Ludox cause significantly less osmotic stress than sucrose, and the technique does not fail for non-motile or dead individuals.

41. (B) To remove sugar and prevent permanent osmotic damage
High concentrations of sucrose exert severe osmotic pressure on nematode bodies, rapidly drawing out water and causing cellular distortion or death. Rinsing the recovered nematodes on an ultra-fine five hundred-mesh sieve immediately after flotation is critical. This process washes away the sugar residue, restoring the osmotic balance and preserving morphological features for accurate microscopic identification.

42. (C) Induce virtually no osmotic stress on the nematodes
Silica colloidal solutions, such as Ludox, are highly advantageous for density gradient centrifugation because they are non-hypertonic. Unlike sucrose, these colloidal particles do not exert high osmotic pressure on the specimens. This preservation prevents cuticle distortion and internal cellular shrinkage, maintaining the nematodes in a natural state that is highly suitable for taxonomic study.

43. (D) Inactive eggs and sluggish adult stages (e.g., Criconemella)
Non-motile life stages, such as inactive eggs, sluggish adult ring nematodes, or dead specimens, are poorly recovered by behavioral methods like the Baermann funnel. Centrifugal flotation relies strictly on physical density and buoyancy rather than movement. This makes it highly efficient for capturing these inactive stages, providing a complete and unbiased representation of the soil population.

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44. (B) 1750 to 2000 rpm for 4 to 5 minutes
Standard sugar flotation protocols require precise control of centrifugal forces to separate nematodes without causing physical damage. Spinning the tubes at seventeen hundred fifty to two thousand revolutions per minute for four to five minutes provides the optimal force. This duration ensures complete pelleting of soil particles while allowing nematodes to float into the sucrose supernatant.

45. (B) The specific gravity of the sucrose solution was too low.
If nematodes remain trapped in the soil pellet after the second centrifugation step, the density of the flotation medium is incorrect. A sucrose solution with a specific gravity below the required 1.18 threshold fails to provide the necessary buoyant force. Consequently, the nematodes do not float and are discarded with the heavy mineral pellet at the bottom.

46. (B) Fine undecomposed organic matter that floats in sugar
Soils containing high levels of fine, undecomposed organic matter are difficult to process using centrifugal flotation. This organic debris has a low specific gravity similar to nematodes, causing it to float in the sucrose solution during centrifugation. The resulting supernatant

is highly contaminated with debris, making microscopic viewing and accurate counting of the nematodes extremely difficult.

47. (A) To dissolve the gelatinous matrix holding the eggs
Recovering nematode eggs from the protective gelatinous matrices of Meloidogyne species requires breaking down the mucilaginous envelope. Utilizing a dilute solution of sodium hypochlorite during extraction chemically dissolves this mucilaginous envelope. This releases the individual eggs into suspension, allowing them to be separated from root debris and recovered cleanly through subsequent centrifugal flotation steps.

48. (B) 454 g per liter of water (1 lb/liter)
To prepare the standard flotation medium, a precise concentration of sugar must be dissolved in water. Mixing approximately four hundred fifty-four grams of sucrose per liter of water yields a solution with a specific gravity of 1.18. This density is ideal for floating most plant-parasitic nematodes while allowing heavier mineral soil components to sink.

49. (D) Cysts of Heterodera and Globodera
The Fenwick can is a specialized, classic apparatus engineered specifically for the extraction of cyst-forming nematodes, such as Heterodera and Globodera. It exploits the unique physical properties of mature cysts, which are buoyant and float when dry. This design allows for the efficient processing of large soil volumes to monitor these highly regulated quarantine pests.

50. (A) Soil drying → Washing over the sloping collar → Floating cysts pass to the overflow → Collection on sieves
Extracting cysts using the Fenwick can follows a precise chronological sequence of physical steps. The soil sample is first thoroughly dried to ensure the cysts are filled with air and buoyant. Washing the soil over the sloping collar floats the cysts into the overflow water stream, which is then captured on fine sieves for microscopic examination.

51. (B) To ensure the cysts fill with air, increasing their buoyancy
Air-drying soil samples prior to Fenwick can extraction is a critical step in the recovery of cyst nematodes. Drying causes the moisture inside the mature cysts to evaporate, replacing it with air. This significantly decreases their density, making them highly buoyant so they readily float to the surface of the water column during the washing process.

52. (D) To direct upward water flow and cysts into a sieve
The sloping collar of the Fenwick can is designed to manage the flow of water and suspended particles. As water is introduced at the bottom, it creates an upward current that carries the buoyant cysts. The sloping collar directs this overflowing water directly onto a series of collection sieves, preventing the loss of specimens during extraction.

53. (A) Migratory endoparasites from roots
The mist chamber technique is highly efficient for isolating migratory endoparasitic nematodes, such as Pratylenchus and Radopholus, from root tissues. By continuously bathing the roots in a fine mist of water, the apparatus encourages active nematodes to emerge from the cortical tissues. This method maintains root viability during the extraction process, maximizing the yield of live specimens.

54. (C) By spraying a fine mist of oxygenated water over samples
Static extraction methods often suffer from oxygen depletion, which kills nematodes before they can exit plant tissues. The mistifier technique solves this issue by continuously spraying a fine mist of highly oxygenated water over the samples. This continuous water flow ensures a well-aerated environment, keeping both the plant tissues and the target nematodes alive throughout the extraction.

55. (A) The flow of water washes away toxic leachates from the vessel
Chopped roots placed in water often release toxic phenolic compounds and organic acids that can kill emerging nematodes. The mist chamber continuously sprays fresh water over the sample, washing away these harmful plant leachates as they form. This constant washing prevents chemical build-up in the collection vessel, ensuring high survival rates of the extracted nematodes.

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93. (B) Flexible map measurer (opisometer) or digitized software
Nematodes naturally exhibit curved or coiled postures when killed and mounted on slides. Measuring these curved bodies using a straight ruler introduced significant geometric error. Using a flexible map measurer, also known as an opisometer, or specialized digital imaging software allows researchers to trace precisely along the central body axis, yielding accurate total length measurements.

94. (A) 0.1 mm (100 µm) and 0.01 mm (10 µm)
A stage micrometer is a highly precise glass slide etched with a scale of known dimensions. It typically features a total length of one or two millimeters, which is subdivided into primary divisions of 0.1 millimeters and fine divisions of 0.01 millimeters. This standardized scale is essential for calibrating ocular micrometers under different magnifications.

95. (B) 15 µm
Ocular micrometer calibration is calculated by dividing the physical stage distance by the number of aligning ocular units. In this scenario, zero point three millimeters on the stage micrometer is equal to three hundred micrometers. Dividing three hundred micrometers by twenty ocular divisions yields a precise value of fifteen micrometers for each individual division on the scale.

96. (C) Constant movement prevents precise alignment and measurement.
Taking morphometric measurements of live nematodes is extremely difficult due to their continuous, active movement. This motility prevents precise alignment with the micrometer scale or tracing with a camera lucida. Properly heat-killing and fixing the specimens relaxes them into a natural, stationary posture, allowing for stable, reproducible, and highly accurate measurements under the microscope.

97. (D) From the anal opening to the posterior terminus
In nematode taxonomy, the tail is morphologically defined as the region posterior to the alimentary canal's exit. Therefore, measuring tail length requires locating the precise landmarks starting from the anal opening in females, or the cloacal opening in males, and extending to the extreme posterior terminus of the body. Accurate tail metrics are critical for species identification.

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98. (C) L
Morphometric descriptions in nematology utilize standardized symbols to report body dimensions. The uppercase letter L is universally recognized as the mathematical representation for the total body length of a specimen, measured from the anterior tip of the lip region to the posterior terminus of the tail. This metric serves as a foundational reference point in taxonomy.

99. (B) Fluctuate with age/host, while ratios remain more stable
Absolute physical measurements of nematodes can vary significantly based on nutritional status, host plant quality, and age. De Man's formula addresses this variability by utilizing proportional ratios of key body dimensions. These ratios remain relatively stable throughout the adult stage, providing more reliable taxonomic criteria for distinguishing species than simple, fluctuating absolute lengths.

100. (A) Both A and R are true and R is the correct explanation of A.
In De Man's morphometric system, the value V represents the position of the vulva along the body. This ratio is always expressed as a percentage because it is calculated by dividing the distance from the head to the vulva by the total body length, then multiplying by one hundred. This standardization allows for direct comparison between specimens.

101. (A) Total body length divided by greatest body width
The De Man morphometric ratio designated by the letter 'a' describes the overall proportional slimness of a nematode's body. It is calculated by dividing the total body length of the specimen by its maximum body width, typically measured at the vulva or mid-body. A higher 'a' value indicates a more slender, filiform body shape.

102. (C) 5.0
The De Man ratio 'b' is a standard taxonomic metric that describes the relative length of the esophagus. It is calculated by dividing the total body length of the nematode by the length of the esophagus. For a specimen with a body length of one thousand micrometers and an esophagus

incubation water serves a dual purpose. It acts as a mild disinfectant to suppress bacterial growth while releasing dissolved oxygen, keeping the emerging nematodes active and viable for microscopic analysis.

66. (C) Chopping bulb scales and placing them in a Baermann funnel
Stem and bulb nematodes, such as Ditylenchus dipsaci, are highly active migratory endoparasites that inhabit the parenchymatous tissue of bulbs. Chopping the infected bulb scales and placing them in a Baermann funnel is the most effective extraction technique. The cut surfaces allow the active nematodes to easily migrate out of the tissue into the water column.

67. (B) Histopathological microtomy and differential staining
Understanding the precise spatial relationships and feeding structures of sedentary endoparasitic nematodes within host tissue requires specialized techniques. Standard extraction methods destroy these physical associations. Performing histopathological microtomy, followed by differential staining, preserves the anatomical structures of both the plant and the nematode. This allows researchers to visually analyze the feeding sites under high magnification.

68. (D) Soaking seeds in warm water to revive anhydrobiotic stages
The foliar nematode Aphelenchoides besseyi survives inside dry rice seeds in a dormant, dehydrated state known as anhydrobiosis. Extracting these nematodes requires soaking the seeds in warm water for several hours. This hydration process revives the dormant individuals, stimulating them to become active and migrate out of the seeds into the water for collection.

69. (A) Inside the roots and migrated out, or newly hatched from eggs
During the prolonged incubation of plant roots in water, nematodes are recovered continuously over several days. Individuals collected on the fifth day were typically located deep within the root tissues initially and required time to migrate out. Alternatively, they may have newly hatched from eggs embedded in the root matrix during the incubation period.

70. (A) P-4, Q-1, R-2, S-3
Optical microscopy techniques provide distinct visual advantages for studying nematodes. Bright-field is standard for stained specimens, while phase-contrast translates phase shifts to enhance transparent structures. Differential Interference Contrast provides pseudo-three-dimensional images with excellent resolution and optical sectioning. Fluorescence microscopy is essential for detecting specific autofluorescent or tagged molecules within the nematode specimens.

71. (A) Numerical aperture (NA) of the objective lens
The resolving power of an optical microscope is limited by the refraction of light as it passes from glass to air. Using immersion oil matches the refractive index of the glass lens, preventing light refraction and loss. This increases the numerical aperture of the objective lens, allowing more light to be collected and significantly improving resolution.

72. (D) It enhances contrast without halos and provides optical sectioning.
Differential Interference Contrast microscopy is highly preferred for analyzing live, unstained nematodes. Unlike phase-contrast, which produces distracting halos around thick specimens, Nomarski optics generate clean, high-contrast images with a distinct three-dimensional appearance. This technique also allows for precise optical sectioning, enabling researchers to focus on specific depth planes within the transparent specimen.

73. (B) The "halo effect" which obscures fine boundary details
Phase-contrast microscopy relies on light diffraction to generate contrast in transparent specimens. However, when applied to thick specimens like mature nematodes, light refraction at the boundaries creates a bright, glowing "halo effect". This optical artifact obscures fine structural details along the margins of the specimen, making precise morphological measurements and identification difficult.

74. (C) The substage condenser and iris diaphragm
The quality of illumination in a compound microscope is regulated by the substage condenser and its integrated iris diaphragm. These components focus and align the light beam onto the specimen, controlling both the intensity and

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the angle of illumination. Proper adjustment is critical to optimize contrast, minimize glare, and match the numerical aperture of the objective.

75. (D) DIC (Nomarski) microscopy
Visualizing the detailed morphology of fine structures, such as stylet knobs, in live, unstained nematodes requires exceptional resolution and contrast. Differential Interference Contrast microscopy is the optimal optical technique for this purpose. It enhances the boundaries of transparent structures without introducing halos, allowing for precise optical sectioning of the head region.

76. (A) Three-dimensional and erect (right-side up)
Stereomicroscopes are designed with dual optical paths that project slightly different angles of the specimen to each eye. This binocular configuration produces a realistic, three-dimensional image with deep perception. Additionally, the optical design ensures the image is erect and not inverted, which greatly facilitates the manual manipulation, picking, and transferring of individual nematodes.

77. (B) The specimen remains relatively in focus when switching objectives
Parfocality is an essential optical design feature of modern compound microscopes. It ensures that when the user switches from a low-power objective to a higher magnification, the specimen remains relatively in focus. Only minor adjustments using the fine focus knob are required, saving time and preventing the objective lens from accidentally hitting the slide.

78. (B) Stereomicroscopy (dissecting microscope)
Routine tasks such as counting, sorting, and physically picking individual nematodes from aqueous suspensions require a wide field of view and ample working distance. Stereomicroscopy provides these features along with a three-dimensional, upright image. This makes it the indispensable tool for manipulating specimens under low magnification before high-resolution study on a compound microscope.

79. (B) 1000x to 1500x
The magnification of a light microscope is fundamentally limited by the wavelength of visible light and the numerical aperture of the lenses. The maximum theoretical useful magnification using high-quality oil immersion objectives is approximately one thousand to fifteen hundred times. Increasing magnification beyond this limit results in empty magnification, where the image enlarges but yields no additional structural detail.

80. (B) I, II, IV and V
Preparing nematodes for electron microscopy involves a sequence of precise chemical and physical steps. Glutaraldehyde and osmium tetroxide are standard fixatives for cellular structures and lipids, respectively. Sputter coating provides conductivity for scanning electron microscopy, and ultramicrotomy is essential for generating thin sections for transmission electron microscopy. However, critical point drying is necessary to prevent cuticle collapse.

81. (D) To avoid surface tension forces that distort the cuticle
During preparation for scanning electron microscopy, wet specimens must be completely dried before being placed in a high vacuum. Air-drying creates intense surface tension forces at the liquid-gas interface, which collapses and distorts the delicate nematode cuticle. Critical point drying avoids these destructive forces by transitioning the liquid phase directly to gas at supercritical parameters.

82. (C) Passes electrons through thin sections for internal ultrastructure
Transmission electron microscopy operates on a fundamentally different principle than scanning electron microscopy. While scanning microscopy scans the surface to map three-dimensional topography, transmission microscopy passes an electron beam directly through ultra-thin specimen sections. This allows researchers to visualize internal cellular organelles, membranes, and macromolecular structures at extremely high resolution.

83. (B) Epoxy resin (e.g., Spurr's or Epon)
Preparing nematode specimens for transmission electron microscopy requires an embedding medium that can withstand the high-vacuum environment and be cut into ultra-thin sections. Epoxy resins, such as Spurr's or Epon, are the industry standard. These resins infiltrate the tissues thoroughly and polymerize into a hard plastic block that supports delicate structures during sectioning.

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84. (D) Ethanol or acetone
Before embedding nematode specimens in non-polar epoxy resins for electron microscopy, all internal water must be completely removed. This dehydration process is performed using an ascending gradient of ethanol or acetone. This gradual replacement of water prevents osmotic shock and cellular distortion, ensuring the internal ultrastructure is preserved in its natural state.

85. (A) The impermeable nature of their collagenous cuticle
The nematode cuticle is a highly specialized, multi-layered collagenous structure designed to protect the animal from chemical and physical hazards in the soil. However, this protective barrier is highly impermeable to standard chemical fixatives used in electron microscopy. This resistance makes the fast and uniform preservation of internal cellular structures uniquely challenging for researchers.

86. (C) By physically cutting the nematode in half while immersed
To overcome the barrier of the impermeable cuticle during fixation for electron microscopy, researchers must facilitate direct chemical entry. Physically cutting the nematode in half while immersed in the fixative solution is a standard and effective technique. This provides an immediate pathway for the chemicals to penetrate and preserve the delicate internal organs before degradation occurs.

87. (A) Provide a conductive surface that prevents electron charge build-up
In scanning electron microscopy, the electron beam scans the specimen surface, depositing electrical charges. Because biological tissues are non-conductive, this causes charge accumulation, leading to severe image distortion and thermal damage. Sputter coating the dried nematode with a thin layer of gold or palladium creates a conductive surface, allowing charges to dissipate safely.

88. (D) Surface topography of the lip region and amphidial apertures
Scanning electron microscopy is uniquely suited for examining the three-dimensional surface features of specimens. The complex surface topography of the nematode lip region, along with fine sensory structures like amphidial apertures and labial papillae, are best studied using this technique. It provides exceptional depth of field and high-resolution images of these external taxonomic landmarks.

89. (B) Transmission Electron Microscope (TEM)
Analyzing the internal, sub-cellular details of nematode anatomy, such as the organelles within the stylet-secreting glands, requires extreme resolution beyond the capabilities of light microscopy. Transmission electron microscopy is the necessary instrument for this work. By passing electrons through ultra-thin sections, it reveals the cellular membranes, secretory vesicles, and endoplasmic reticulum in exquisite detail.

90. (A) 1, 2, 3, 4, 5
Calibrating an ocular micrometer requires a systematic sequence of steps to ensure accurate microscopic measurements. The ocular scale is first inserted into the eyepiece, followed by focusing on the stage micrometer. Superimposing the scales and aligning their zero lines allows the user to calculate the precise distance represented by one ocular division for that specific magnification.

91. (D) Superimposing images onto paper for accurate hand-drawing
The camera lucida, or drawing tube, is a classic optical attachment that projects a superimposed image of the microscope field onto a drawing surface. This allows the researcher to trace the outline and internal structures of the nematode with high geometric accuracy. This method remains a valuable tool for creating standardized taxonomic illustrations and scientific diagrams.

92. (A) Must be recalculated or adjusted for other objective lenses
The calibration value of an ocular micrometer is specific to the magnification of the objective lens being used. Because different objectives project different image sizes onto the eyepiece, the distance represented by each ocular division changes. Therefore, the calibration must be recalculated for every objective lens on the microscope to ensure accurate specimen measurements.

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acetic acid, brought to one hundred milliliters with distilled water.

113. (D) Adding boiling water or hot double-strength fixative
The most efficient and safe method to heat-kill nematodes in the laboratory is by rapidly introducing thermal energy. This is standardly done by adding an equal volume of boiling water or hot, double-strength chemical fixative directly to the nematode suspension. This instant temperature increase quickly kills and relaxes the specimens without boiling or damaging them.

114. (C) The same fixative solution used initially
To prevent biological degradation and maintain structural integrity, fixed nematodes must be stored under stable chemical conditions. Keeping the specimens in tightly sealed vials containing the original fixative solution is recommended. This continuous exposure prevents the samples from drying out or decomposing, preserving their taxonomic features until they are ready for clearing and mounting.

115. (B) 37-40%
Formalin is a widely used biological preservative, but its terminology can be confusing. It is defined as a saturated aqueous solution of formaldehyde gas, which reaches a maximum concentration of approximately thirty-seven to forty percent by weight. Diluting this stock solution is necessary to prepare the standard four percent formaldehyde solutions used for fixing nematodes.

116. (D) Ethanol (Alcohol)
The addition of ethanol in the FAA (Formalin-Aceto-Alcohol) fixative serves a critical physiological function. Ethanol acts as a penetrating agent that quickly breaches the naturally impermeable collagenous cuticle of the nematode. This rapid penetration allows the formaldehyde and acetic acid to enter the body cavity and fix the internal tissues before cellular decay begins.

117. (A) To match refractive indices, making internal details highly visible
Fixed nematodes are often opaque, obscuring internal anatomical details under light microscopy. Clearing the specimens to pure glycerine replaces internal water with a medium that matches the refractive index of the glass slide and coverslip. This optical synchronization makes the nematode body highly transparent, revealing fine structures like the esophagus, gonads, and spicules clearly.

118. (C) Ethanol
Seinhorst's rapid method is a classic technique used to transition fixed nematodes from aqueous fixatives to pure glycerine. This process utilizes ethanol as a highly volatile solvent to gradually extract moisture from the tissues. By slowly replacing water with glycerine under controlled evaporation, the method prevents the osmotic collapse of the specimens during dehydration.

119. (A) Placed in a desiccator to allow slow evaporation
The slow glycerol-ethanol method is designed to prevent osmotic shock in delicate nematode specimens. Fixed nematodes are placed in a dilute mixture of glycerine, ethanol, and water, which is then kept in a closed desiccator. This environment allows the alcohol and water to evaporate extremely slowly, leaving the nematodes cleared in pure, anhydrous glycerine over several weeks.

120. (C) Only III
Processing nematodes to pure glycerine requires care to avoid structural damage. Rapid transfer into concentrated glycerine causes severe, irreversible osmotic shrinkage. While Seinhorst's slow method successfully prevents this shock, completely cleared and dehydrated nematodes in pure glycerine do not appear black; instead, they are highly transparent and optically clear under compound light microscopy.

121. (B) Lactic acid, Glycerine, and Phenol
The rapid clearing method developed by Baker utilizes a specialized mixture of lactic acid, glycerine, and phenol. This chemical combination rapidly penetrates fixed tissues and clears the nematode body, making it highly transparent in a fraction of the time required by slow evaporation methods. This rapid protocol is highly useful for quick diagnostic identifications.

122. (C) To prevent absorption of moisture by hygroscopic glycerine.
Pure glycerine is a highly hygroscopic substance, meaning it actively absorbs water vapor from the surrounding atmosphere. If permanent slides are left unsealed, moisture absorption will dilute the mounting medium, causing the coverslip to drift

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of two hundred micrometers, the ratio is exactly 5.0.

103. (A) Tail length relative to body length
The De Man morphometric ratio 'c' is an important taxonomic descriptor used to characterize the tail of a nematode. It is calculated by dividing the total body length of the specimen by its tail length. A low 'c' value indicates a relatively long tail, whereas a high value represents a short, blunt tail structure.

104. (D) Tail length divided by the body width at the anus
The morphometric ratio denoted as c-prime is a critical diagnostic character, particularly in female nematodes. It is calculated by dividing the total tail length by the body width measured at the anus or cloaca. This ratio provides a standardized description of tail shape, helping taxonomists distinguish between closely related species with similar absolute tail lengths.

105. (B) 50%
The V percentage is a fundamental morphometric ratio in female nematode taxonomy. It represents the distance from the anterior end of the body to the vulva, expressed as a percentage of the total body length. If a female nematode has its vulva positioned exactly in the middle of its body, the calculated value is fifty percent.

106. (C) The ratio of the length of the conus to total stylet length
The stylet is a complex feeding apparatus whose shape and proportions are critical for identification. In detailed morphometric descriptions, the parameter designated by the letter 'm' represents the length of the anterior conus expressed as a percentage of the total stylet length. This specific ratio helps differentiate genera within the order Tylenchida.

107. (D) o (or O ratio)
The position of the dorsal esophageal gland orifice relative to the stylet knobs is an important diagnostic character in tylenchid nematodes. This distance is measured and expressed as a percentage of the total stylet length, denoted by the letter 'o'. This metric is highly consistent and helps distinguish species within genera like Meloidogyne.

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108. (A) It kills the nematode in a relaxed, straight, or natural posture.
Plant-parasitic nematodes must be killed before chemical evaluation. Gentle heating in hot water at sixty to sixty-five degrees Celsius is the standard method. This temperature relaxes the muscles, causing the nematodes to die in a straight or naturally slightly curved posture, which is ideal for mounting and subsequent microscopic measurement.

109. (B) They undergo severe spasms, becoming contorted and unsuitable.
Direct exposure of live, active nematodes to cold chemical fixatives like formalin triggers a severe physiological stress response. The organisms undergo intense muscle spasms, dying in highly contorted, twisted, or distorted postures. These damaged specimens are completely unsuitable for taxonomic studies because their bent bodies prevent accurate morphometric measurements and make internal structures difficult to view.

110. (A) P-1, Q-2, R-3, S-4
Standard nematode fixatives are formulated with specific chemical combinations to optimize preservation. FA (4:1) contains formalin, acetic acid, and water, while FAA adds ethanol to accelerate cuticle penetration. TAF utilizes triethanolamine to prevent specimen hardening, and Ditlevsen's fixative combines formalin, acetic acid, glycerin, and water. Matching the fixative to the study requirement ensures optimal preservation.

111. (A) TAF (Triethanolamine Formalin)
Triethanolamine Formalin, commonly abbreviated as TAF, is a highly favored fixative in nematology. The addition of triethanolamine prevents the tissues from becoming overly hard and brittle, which is a common issue with pure formalin. TAF keeps the specimens relatively soft and lifelike, maintaining clear diagnostic features for long-term storage and subsequent mounting.

112. (C) 10 mL Formalin, 1 mL Glacial acetic acid, and 89 mL water
The traditional fixative known as FA (4:1) is a standard solution used for preserving nematode specimens. The naming convention refers to the ratio of formalin to glacial acetic acid. The final formulation is prepared by mixing ten milliliters of standard formalin with one milliliter of glacial

56. (D) Oostenbrink elutriator
Elutriation is a physical separation process that uses an upward stream of water to sort particles based on density and settling velocity. The Oostenbrink elutriator is designed specifically on this principle. It separates relatively light nematodes from heavier mineral soil particles by balancing the upward water current against the gravitational settling rate of the different components.

57. (B) Fragments washing into the sample, creating a dirty suspension
A primary limitation of using the mist chamber technique with highly fragmented or small root samples is particulate contamination. The continuous flow of water can wash fine root debris through the supporting screens and into the final collection beaker. This creates a highly contaminated suspension, making microscopic counting of the extracted nematodes difficult and time-consuming.

58. (C) Specific gravity using heavy liquids
The Schuiling centrifuge is a specialized diagnostic tool designed for high-throughput extraction of nematode cysts. Unlike standard buoyancy-based methods, this technique heavily manipulates the specific gravity of the flotation medium using concentrated heavy liquids. This density modification, combined with centrifugal force, rapidly separates the cysts from mineral debris with exceptional speed and precision.

59. (D) Increase surface area for water penetration and egress
Preparing root samples by chopping them into small pieces of one to two centimeters is essential before mist chamber extraction. This mechanical processing increases the surface area of the root tissue, facilitating water penetration into the cortical layers. It also creates numerous exit points, allowing endoparasitic nematodes to migrate out of the tissue more rapidly.

60. (A) Both A and R are true and R is the correct explanation of A.
The maceration-blending technique significantly improves the extraction of endoparasitic nematodes from plant roots when followed by a Baermann tray. This mechanical processing physically cuts and breaks open the tough cortical tissues, releasing trapped nematodes. Increasing the exposed surface area of the tissue allows more individuals to migrate into the water, resulting in higher recovery rates.

61. (B) High risk of microbial growth and oxygen depletion
The static incubation of plant roots in shallow water is an inexpensive extraction method but has significant drawbacks. Without continuous water flow or aeration, the stagnant environment rapidly promotes bacterial and fungal contamination. This microbial growth depletes dissolved oxygen, creating anaerobic conditions that kill the emerging nematodes and cause rapid tissue decay.

62. (B) Sodium hypochlorite (NaOCl) agitation
Recovering nematode eggs from the protective gelatinous matrices of Meloidogyne species requires breaking down the mucilaginous envelope. Agitating the infected roots in a dilute solution of sodium hypochlorite is the standard chemical method used. This treatment rapidly dissolves the matrix proteins, releasing the eggs without damaging their chitinous shells, allowing for easy collection and quantification.

63. (A) 10 to 15 seconds
When using a mechanical blender to process root tissues for nematode extraction, timing is critical. Operating the blender for ten to fifteen seconds is sufficient to chop the roots and open the cortical tissues. This short duration minimizes physical damage to the nematodes while effectively releasing them from the protective plant matrix for collection.

64. (C) Mechanical destruction and shearing of the nematodes
Subjecting root tissues to excessively long blending times during extraction is highly detrimental to nematode recovery. The high-speed rotation of the blender blades creates intense mechanical shear forces that physically damage or destroy the nematodes. This shearing makes the specimens unidentifiable, severely underestimating the actual population density present within the root samples.

65. (D) Suppressing bacteria and supplying oxygen to nematodes
Stagnant water used during root incubation is prone to rapid bacterial colonization and subsequent oxygen depletion. Adding a low concentration of hydrogen peroxide to the

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and promoting microbial growth. Thoroughly sealing the coverslip edge with ringing cement prevents this contamination and preserves the slide.

123. (D) Prevent nematodes from being crushed by the coverslip
Placing glass fiber supports or microscopic glass beads under the coverslip is a critical step in slide preparation. These physical barriers match the approximate diameter of the mounted specimens, bearing the weight of the coverslip. This prevents the pressure of the glass from flattening or crushing the nematodes, preserving their natural morphometrics for accurate taxonomic study.

124. (A) Melts when heated, sealing the coverslip and embedding supports
The wax-ring method is an elegant, rapid technique for preparing permanent nematode mounts. A thin ring of paraffin wax is placed on the slide around the glycerine drop. When heated on a hotplate, the wax melts, allowing the coverslip to settle onto the glass supports while simultaneously forming a durable, hermetic seal around the glycerine.

125. (B) Viewing of the nematode specimen from both sides
Cobb's classic aluminum double-coverslip slide is a specialized design used in high-resolution nematology. By suspending the coverslip-sandwiched specimen within an open aluminum frame, the slide allows light to pass through from either direction. This unique design enables taxonomists to flip the slide and examine fine anatomical details of the nematode from both the dorsal and ventral sides.

126. (B) Water or the killing/fixing solution
Temporary mounts are prepared for rapid diagnostic examinations when long-term specimen preservation is unnecessary. These mounts are typically made by placing the nematodes directly in a drop of water or the initial killing and fixing solution on a glass slide. This simple setup is sufficient for immediate morphological viewing but will dry out quickly if not sealed.

127. (A) The coverslip edge is clean and free of excess glycerine
Applying ringing cement to seal a permanent glycerine mount requires a completely clean substrate. If any excess glycerine is present on the coverslip or slide surface, the cement will fail to adhere properly, creating gaps in the seal. Thoroughly cleaning the edges before application ensures a durable, airtight bond that prevents moisture absorption.

128. (C) It acts as both the coverslip support and the primary seal.
The wax-ring mounting method offers significant advantages over liquid ringing cements. The solidified paraffin wax serves a dual purpose: it acts as a physical spacer to support the coverslip, preventing nematode crushing, while simultaneously providing a durable, airtight seal around the glycerine. This simplifies slide preparation and eliminates the need for manual ringing.

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129. (D) Small pieces of glass rods or spun glass fibers
To prevent morphological distortion, the coverslip supports must match the physical thickness of the mounted specimens. For large nematodes like Xiphinema, small pieces of glass rods or spun glass fibers are ideal. Selecting fibers of corresponding diameter ensures the coverslip rests evenly without compressing the nematode body, maintaining accurate taxonomic morphometrics.

130. (A) Both A and R are true and R is the correct explanation of A.
Utilizing glass fiber supports is an essential step when preparing permanent slide mounts of nematodes. The weight and capillary pressure of the coverslip can easily compress and deform the delicate, soft bodies of the specimens. This mechanical flattening alters critical morphometric dimensions, such as body width and ratios, leading to incorrect taxonomic identifications.

131. (C) 1.47
Optical microscopy of transparent biological specimens depends heavily on the refractive index of the mounting medium. Pure glycerine has a refractive index of approximately 1.47, which is very close to that of crown glass. This optical similarity minimizes light scattering at

188. (A) The symbiotic bacteria established first
Mass production of entomopathogenic nematodes in liquid fermentation requires a two-step inoculation process. The bioreactor must first be inoculated with the mutualistic symbiotic bacteria, allowing them to multiply and establish a primary phase culture. Once the bacterial population is dense, the infective juvenile nematodes are introduced to feed and reproduce in the liquid medium.

189. (B) Maintaining the primary phase variant of Photorhabdus
Scaling up liquid fermentation for Heterorhabditis production is technically demanding due to bacterial instability. The symbiotic bacteria, Photorhabdus, can spontaneously shift from the highly nutritious primary phase variant to an unproductive secondary phase during fermentation. Maintaining the primary phase is critical, as the secondary phase fails to support optimal nematode growth and reproduction in the bioreactor.

190. (B) Only III
Proving the pathogenicity of plant-parasitic nematodes using Koch's postulates requires strict experimental adherence. The target nematode must be constantly associated with the disease, isolated in pure culture, and used to inoculate healthy hosts to reproduce symptoms. Substituting a closely related species during the re-inoculation phase is scientifically invalid, making that specific statement incorrect.

191. (A) They are obligate biotrophs requiring living plant tissue
Applying Koch's postulates to plant-parasitic nematodes is uniquely challenging due to their specialized biology. Most plant parasites are obligate biotrophs, meaning they cannot live or reproduce on artificial agar media lacking host cells. This feeding requirement makes isolating and culturing them in completely pure, axenic cultures extremely difficult compared to saprophytic species.

192. (C) Autoclaving at 121°C and 15 psi and repeating after 24 hours
Pathogenicity trials require completely sterile growth media to prevent interference from resident pests. Autoclaving soil at one hundred twenty-one degrees Celsius and fifteen pounds per square inch is the most reliable sterilization method. Repeating this process after twenty-four hours ensures that any resilient bacterial endospores that germinated after the first cycle are completely destroyed.

193. (D) To confirm symptoms are strictly due to the nematode
Pathogenicity experiments must prove that observed symptoms are caused specifically by the target pathogen. Including an uninoculated control treatment grown under identical conditions is essential. This control provides a baseline showing healthy plant growth, confirming that any stunting, chlorosis, or root damage observed in the inoculated treatments is due solely to the introduced nematode population.

194. (C) Hawksley slide or Peters' 1 ml counting chamber
Standardizing the nematode concentration for inoculation in pot experiments requires precise quantification of the stock suspension. This calibration is standardly performed by drawing representative aliquots and counting the nematodes using a specialized Hawksley slide or a Peters' one-milliliter counting chamber. This ensures that each experimental plant receives a known, uniform number of nematodes.

195. (B) Field stunting was caused by a disease complex absent in the lab.
In agricultural fields, plants are often exposed to multiple pathogens simultaneously, resulting in synergistic disease complexes. If a researcher fails to reproduce field stunting in a greenhouse using isolated nematodes alone, it suggests other soil-borne fungi or bacteria were involved. The single-pathogen greenhouse trial lacks these cooperating organisms, failing to duplicate the complex field symptoms.

196. (D) Pipetting suspension into small holes near the root zone
Introducing nematodes into experimental pots must be done carefully to ensure high survival and infection rates. Pipetting the calibrated nematode suspension into several small holes made directly in the soil near the plant's root zone is recommended. This places the infective stages in close physical proximity to the active feeder roots, facilitating rapid invasion.

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binds specifically to the proteinaceous gelatinous matrix of the egg masses. It colors these structures a bright red while leaving the roots unstained, enabling rapid visual quantification.

142. (B) The destaining process in acidified glycerine
If a stained root sample shows no contrast, with both the roots and nematodes colored uniformly deep red, the protocol failed. This issue is typically caused by an omitted or insufficient destaining step in acidified glycerine. Without this chemical clearing, the dye remains bound to the plant cell walls, obscuring the nematodes within the tissue.

143. (A) Observation of nematodes in undisturbed natural feeding sites
While mechanical maceration extracts nematodes for counting, it destroys the physical architecture of the host tissue. Root staining methods offer the unique advantage of preserving the spatial relationships between the parasite and the plant. This allows researchers to observe nematodes within their undisturbed, natural feeding sites, providing valuable ecological and histographical data.

144. (C) Stereomicroscope with transmitted sub-stage lighting
Properly evaluating whole-root systems stained with acid fuchsin requires a wide field of view and high-contrast illumination. A dissecting stereomicroscope equipped with transmitted sub-stage lighting is the most effective tool. The light passing through the cleared roots from below highlights the intensely stained red nematodes, allowing for easy scanning and counting across entire root systems.

145. (D) Formalin-Aceto-Alcohol (FAA)
Histopathological studies require the rapid and uniform preservation of both plant and nematode cell structures. Formalin-Aceto-Alcohol, commonly known as FAA, is the standard fixative used for this purpose. The alcohol accelerates penetration through the tissues, while the formalin and acetic acid fix proteins and minimize cellular shrinkage, preserving delicate histological relationships in their natural state.

146. (C) Remove water to allow infiltration by paraffin wax
Before embedding root samples in paraffin wax for sectioning, all water must be removed from the tissues. Paraffin wax is highly hydrophobic and completely immiscible with water. Dehydrating the fixed roots through an ascending series of ethanol or alcohol gradually replaces internal water, preparing the tissues for successful infiltration by the wax embedding medium.

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147. (B) Paraffin wax
Sectioning delicate plant tissues on a microtome requires a medium that provides solid structural support. Paraffin wax is the standard embedding medium used in plant histopathology. Once the tissue is dehydrated and cleared, molten paraffin is infiltrated into the roots and allowed to solidify into a hard block, facilitating the cutting of ultra-thin, continuous sections.

148. (B) 10 to 15 μm
Preparing root sections for light microscopy requires a precise slice thickness that balances cellular detail with structural integrity. Slicing paraffin-embedded tissues at ten to fifteen micrometers is standard. This thickness provides clear, single-cell layers under the microscope without tearing, allowing researchers to observe the spatial arrangements of giant cells and feeding nematodes.

149. (A) Safranin and Fast Green
Safranin and Fast Green is a classic, highly effective double-stain combination used in plant histology. Safranin has an affinity for lignified, suberized cell walls and chromatic materials, staining them bright red. Fast Green selectively colors unlignified cellulose walls and cytoplasm a vibrant green. This contrast clearly differentiates host structures from the invading nematode.

150. (D) I, II, III and IV
Plant histopathology protocols rely on a series of precise chemical reactions to achieve high-contrast sections. Safranin and Fast Green differentially stain tissues red and green, respectively. Microtome ribbons must be flattened on warm water before mounting, and xylene is necessary to deparaffinize the sections, allowing subsequent aqueous stains to penetrate the embedded root tissues.

host plants. Achieving this requires specialized liquid media containing complex nutrients, allowing for studies on nematode physiology free from microbial interactions.

170. (D) A is false but R is true.
Establishing axenic cultures of obligate plant-parasitic nematodes on simple agar media is extremely difficult because they require living host tissues to feed and reproduce. This makes the assertion false. However, under specialized laboratory conditions, some nematodes can absorb dissolved organic nutrients directly through their cuticle and oral openings, which supports the physiological reasoning of the statement.

171. (D) In association with only one other known living organism
Monoxenic culture is a highly controlled rearing technique used to study plant-parasitic nematodes in isolation from environmental contamination. It is defined as cultivating a single nematode species in association with only one other known living organism, such as a specific host plant root or fungal culture. This method ensures that all observed interactions are strictly bilateral.

172. (A) Carrot discs in sealed petri dishes
Rearing migratory endoparasitic nematodes of the genus Pratylenchus is highly successful using the carrot disc technique. Fresh, sterile carrot discs placed in sealed petri dishes provide a nutrient-rich, semi-solid tissue environment. The nematodes feed and multiply rapidly within the parenchyma cells of the disc, yielding large, clean, and uncontaminated populations for research purposes.

173. (B) Agrobacterium rhizogenes-induced "hairy roots"
Genetically transformed plant tissues provide an excellent substrate for monoxenic nematode culture. Inoculating plant cells with the bacterium Agrobacterium rhizogenes induces the formation of highly branched, fast-growing "hairy roots". These transformed roots grow vigorously in vitro on hormone-free media, providing a continuous, sterile, and highly stable tissue system for rearing sedentary endoparasites like Meloidogyne.

174. (B) Surface-sterilized to remove contaminating bacteria/fungi
Nematodes collected from field soil or non-sterile greenhouse plants are heavily contaminated with associated soil bacteria, fungal spores, and other microbes. Before these nematodes can be introduced into monoxenic in vitro cultures, they must undergo thorough surface-sterilization. This step is critical to prevent microbial growth from overgrowing the sterile root tissue and ruining the culture.

175. (A) Dilute sodium hypochlorite (NaOCl) and antibiotics
Surface sterilizing nematode juveniles or eggs for in vitro culture requires chemicals that eliminate surface microbes without killing the nematode. A combination of dilute sodium hypochlorite and a cocktail of broad-spectrum antibiotics is standardly used. The hypochlorite acts as a rapid disinfectant, while the antibiotics prevent any surviving bacterial cells from multiplying on the sterile culture media.

176. (C) Carrot discs or excised root explants
Radopholus similis, the burrowing nematode, is a destructive migratory endoparasite of bananas and citrus. In laboratories, this species is routinely maintained in monoxenic cultures using sterile carrot discs or excised root explants on agar media. This controlled environment supports rapid reproduction of the nematode, providing a continuous supply of high-quality, sterile inoculum for experimental studies.

177. (D) Migratory endoparasites like Pratylenchus and Ditylenchus
Callus culture utilizes undifferentiated masses of plant cells grown on hormone-rich agar media as a host tissue. This system is exceptionally well-suited for rearing migratory endoparasitic nematodes, such as species of Pratylenchus and Ditylenchus. These nematodes can migrate freely and feed on the loose, parenchymatous cells, reproducing rapidly without requiring the structural organization of intact root systems.

178. (C) To sustain excised plant roots or callus tissues
Murashige and Skoog medium, commonly referred to as MS medium, is a highly enriched nutrient formulation used in plant tissue culture. In monoxenic nematode rearing systems, MS medium does not feed the nematodes directly.

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agar is first prepared and poured into plates. The agar is then seeded with a culture of Escherichia coli OP50 and incubated overnight to establish a lawn, after which individual nematodes are transferred using a flamed platinum wire pick.

161. (D) It forms a thin lawn allowing easier worm visualization.
The uracil-auxotroph strain OP50 of Escherichia coli is highly favored for C. elegans research because of its restricted growth characteristics. On standard NGM agar, this bacterium cannot multiply excessively, resulting in a thin, uniform, and translucent lawn. This prevents the bacteria from overgrowing the plates, allowing researchers to easily observe, track, and manipulate the nematodes under a dissecting microscope.

162. (C) It kills post-embryonic stages while leaving eggs intact.
Establishing age-synchronized cultures of C. elegans is essential for reproducible developmental assays. Treating a mixed-stage population with an alkaline hypochlorite bleaching solution achieves this goal. The harsh chemical quickly dissolves the bodies of all larvae and adults, but is resisted by the protective chitinous shells of the eggs. The surviving eggs then hatch synchronously.

163. (B) 15°C to 25°C
Temperature is a critical environmental factor regulating the development and physiology of Caenorhabditis elegans. The optimal temperature range for standard laboratory cultivation is between fifteen and twenty-five degrees Celsius, with twenty degrees being the standard. Temperatures above this range can induce stress and trigger dauer formation, while colder temperatures significantly slow development rates.

164. (B) 3 to 4 days
Caenorhabditis elegans is valued for its rapid life cycle, which allows for high-throughput multi-generational studies. Under optimal laboratory conditions at twenty degrees Celsius, the generation time from an egg to a mature, egg-laying adult is exceptionally short, taking only three to four days. This rapid development enables fast experimental turnaround times compared to other animal models.

165. (A) A stress-resistant developmental stage formed under starvation
When environmental conditions deteriorate, Caenorhabditis elegans can alter its developmental pathway. Under starvation, high population density, or elevated temperatures, the J2 larva molts into an alternative, specialized stage called a dauer larva. This stage is highly stress-resistant, non-feeding, and possesses a modified, impermeable cuticle that allows the nematode to survive harsh conditions for months.

166. (C) Flattened platinum wire attached to a glass rod (worm pick)
Manipulating individual microscopic nematodes without causing physical injury requires a delicate touch and specialized instruments. A worm pick, constructed from a fine, flattened platinum wire attached to a glass rod or inoculation holder, is the standard tool. Platinum is chosen because it can be sterilized rapidly in an open flame and cools almost instantly, preventing heat damage to the worms.

167. (A) Moistened oatmeal or wheat germ
Panagrellus redivivus, commonly known as the sour paste nematode, is a free-living species frequently cultured as a live food source for aquaculture. Unlike C. elegans, it does not require sterile agar media. This species multiplies rapidly on inexpensive, nutrient-rich organic substrates, such as moistened oatmeal or wheat germ, making mass production simple and highly cost-effective.

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168. (D) Fungal growth overgrowing the bacterial lawn
Maintaining healthy, pure cultures of C. elegans requires preventing contamination by non-target organisms. The introduction of filamentous fungi is particularly detrimental to NGM plates. Fungal hyphae grow rapidly across the agar surface, trapping the nematodes, consuming the bacterial food supply, and physically obstructing microscopic viewing, which ultimately ruins the culture plate.

169. (B) Culturing in the absolute absence of other living organisms
In diagnostic and experimental nematology, terminology regarding culture purity is precise. Axenic culture refers to rearing a specific nematode species in the absolute absence of any other living organisms, such as bacteria, fungi, or

151. (A) Multiple hypertrophied nuclei and dense granular cytoplasm
Under microscopic examination, the feeding sites induced by root-knot nematodes exhibit distinct morphological changes. Giant cells are characterized by highly active, dense granular cytoplasm and multiple hypertrophied nuclei. These features reflect the rapid metabolic activity required to sustain the sedentary female nematode, contrasting sharply with the highly vacuolated, single-nucleate normal cortical cells around them.

152. (D) Haupt's adhesive (gelatin/glycerine) or egg albumin
During the multiple chemical rinses of the staining process, paraffin-embedded root sections can easily detach from glass slides. Applying a thin layer of Haupt's adhesive or egg albumin to the slide before mounting is standard practice. These natural proteins coagulate when heated gently on a slide warmer, creating a strong bond that secures the tissue sections.

153. (B) It removes ethanol and makes the tissue transparent.
Before mounting histopathological sections under a coverslip using resinous media like DPX, the tissue must be completely cleared. Xylene is used in the final stages of slide preparation to remove the remaining dehydrating ethanol. This solvent makes the plant tissues highly transparent and is fully miscible with the hydrophobic mounting medium, ensuring bubble-free, permanent slides.

154. (C) Syncytium
Cyst-forming nematodes, such as Heterodera species, induce a highly specialized feeding structure known as a syncytium. Unlike the giant cells of root-knot nematodes, which undergo repeated mitosis without cytokinesis, a syncytium is formed through the progressive dissolution of adjacent cell walls. This causes neighboring protoplasts to merge into a single, massive, multi-nucleate feeding zone.

155. (D) The microtome knife is dull or has a nick.
During microtomy, obtaining smooth, continuous ribbons of sectioned tissue is critical. If the resulting slices appear torn, scraped, or severely fragmented, it indicates a mechanical failure in the cutting process. This issue is most commonly caused by a dull microtome knife or a physical nick along the blade edge, which shears the paraffin block instead of slicing it cleanly.

156. (A) Migratory endoparasites like Pratylenchus
Migratory endoparasites, such as Pratylenchus species, move continuously through the root cortex, feeding on host cells and destroying cell walls. This mechanical and enzymatic damage causes localized necrosis and the formation of dark cavities in the cortical tissue. Because these nematodes do not establish a permanent feeding site, they do not induce specialized structures like giant cells.

157. (B) They serve as excellent genetic and biological model organisms.
The free-living bacterivorous nematode Caenorhabditis elegans is widely cultured in laboratories worldwide. It serves as an exceptional model organism for genetic, developmental, and neurobiological studies due to its simple anatomy, transparent body, and completely mapped genome. It is easy to maintain on inexpensive media, providing a highly reproducible system for fundamental biological research.

158. (B) Nematode Growth Medium (NGM)
Culturing Caenorhabditis elegans requires a specific agar formulation to support both the nematode and its bacterial food source. Nematode Growth Medium, commonly abbreviated as NGM, is the standard choice. This medium contains a precise balance of salts, peptone, cholesterol, and buffer reagents, providing an optimal osmotic environment and nutrition for consistent colony growth.

159. (A) Escherichia coli (strain OP50)
In laboratory cultures, the growth and reproduction of Caenorhabditis elegans depend on a consistent food supply. The bacterium Escherichia coli, specifically the uracil-auxotrophic strain OP50, is standardly seeded onto NGM plates. This strain is chosen because its limited growth on the agar forms a thin, translucent lawn, facilitating the easy visualization and manipulation of the nematodes.

160. (A) Prepare NGM agar → Seed with E. coli OP50 → Incubate overnight → Transfer nematodes using a platinum wire pick
Initiating a new culture of Caenorhabditis elegans requires a structured sequence to maintain purity and viability. Sterilized NGM

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Instead, it provides the essential mineral salts, vitamins, and carbon sources required to sustain the growth of excised host roots or callus tissues.

179. (B) Inside a laminar air flow cabinet using flamed instruments
Maintaining absolute sterility during monoxenic culture transfers is essential to prevent contamination by airborne fungal spores and bacteria. All subculturing procedures must be conducted inside a laminar air flow cabinet, which provides a continuous stream of HEPA-filtered air across the working surface. Researchers must also use thoroughly flamed and cooled instruments during specimen transfer.

180. (A) P-2, Q-1, R-4, S-3
Different nematode groups require specific in vitro culture substrates to support their distinct feeding habits. The fungal-feeding Aphelenchus avenae is reared on fungal cultures, while the migratory Pratylenchus penetrans thrives on carrot discs. The bacterivorous Caenorhabditis elegans is grown on E. coli OP50 lawns, and the sedentary Meloidogyne incognita requires transformed hairy roots for reproduction.

181. (A) Xenorhabdus and Photorhabdus
Entomopathogenic nematodes are highly effective biological control agents due to their obligate mutualistic relationships with specific bacteria. Nematodes of the genus Steinernema carry symbiotic bacteria of the genus Xenorhabdus, while Heterorhabditis species are associated with Photorhabdus bacteria. These bacteria are responsible for killing the insect host and pre-digesting the cadaver tissues for the nematodes.

182. (C) Infective juvenile (IJ), typically a third-stage juvenile
The life cycle of entomopathogenic nematodes includes a unique, highly adapted environmental stage. The infective juvenile, which is a specialized third-stage juvenile, is the only stage capable of surviving in the soil without a host. This non-feeding, sheath-bearing stage actively searches for susceptible insect hosts, initiating infection by entering through natural body openings.

183. (A) Galleria mellonella (Greater wax moth)
Isolating entomopathogenic nematodes from soil samples is standardly performed using an in vivo baiting technique. Larvae of the Greater wax moth, Galleria mellonella, are highly susceptible to these parasites and serve as excellent hosts. Placing these larvae in soil samples allows any infective juveniles present to invade and multiply, simplifying their subsequent recovery.

184. (D) The cadaver becomes brick-red and often exhibits luminescence.
Galleria larvae infected and killed by Heterorhabditis species exhibit distinct diagnostic symptoms. The symbiotic bacteria Photorhabdus, released into the insect hemolymph, produce pigments that turn the cadaver a characteristic brick-red color. Additionally, these specialized bacteria possess bioluminescent properties, causing the freshly killed insect host to glow softly in the dark under laboratory conditions.

185. (B) White trap
Once entomopathogenic nematodes have completed their reproduction inside an insect host, newly developed infective juveniles emerge in massive numbers. The White trap is the standard laboratory device used to harvest these emerging juveniles. This simple apparatus ensures clean, efficient collection of the nematodes in water, separating them from the decaying insect cadaver debris.

186. (C) Cadavers are placed on a moist island; IJs migrate into water.
The White trap operates on a simple physical design that exploits the natural migration behavior of nematodes. Insect cadavers are placed on a moist filter paper island suspended over a shallow pool of water. As the infective juveniles emerge from the cadaver, they migrate across the moist paper and enter the surrounding water, where they collect cleanly.

187. (D) Polyurethane sponge bits soaked with nutrient medium
Solid-state in vitro mass production of entomopathogenic nematodes requires a substrate that provides a high surface-area-to-volume ratio. Polyurethane sponge bits soaked with a rich liquid nutrient medium are standardly used. The porous sponge structure mimics soil pores, providing excellent aeration and physical support for the growth of both the symbiotic bacteria and the reproducing nematodes.

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to stimulate the juveniles to exit the protective cysts. Potato root diffusate, collected from the root systems of growing potato plants, is used as a natural positive control. This diffusate contains specific hatching factors that trigger rapid, high-percentage hatching of species like Globodera.

207. (A) The Lethal Concentration required to kill 50% of the population
The term $LC_{\{50\}}$ represents the calculated Lethal Concentration of a substance required to kill fifty percent of the target nematode population within a specified exposure time. A lower $LC_{\{50\}}$ value indicates a more toxic and potent nematicidal agent.

208. (C) The number of nematodes introduced at the start of the trial
Evaluating host plant resistance requires establishing a known, standardized nematode pressure. The term initial inoculum, mathematically represented as P_i, refers to the precise number of nematodes or eggs introduced into the soil at the very beginning of the experiment. This baseline population is essential for calculating subsequent reproduction rates and host suitability.

209. (D) Final nematode population (P_f) divided by Initial nematode population (P_i)
The Reproduction Factor, denoted as R_f, is a key mathematical metric used to evaluate host suitability in plant nematology. It is calculated by dividing the final nematode population recovered at harvest by the initial population introduced at the start of the experiment. This ratio determines whether the host plant supported or suppressed nematode multiplication.

210. (C) A susceptible host allowing nematode multiplication
Calculating the reproduction factor is fundamental to classifying host status. An R_f value greater than 1.0 indicates that the final nematode population exceeded the initial inoculum level. This shows that the tested plant genotype is a susceptible host that allows the nematodes to successfully feed, mature, and multiply within its root tissues.

211. (B) Tolerant
In plant pathology, resistance and tolerance are distinct biological concepts. A plant variety that supports high nematode reproduction but shows little to no reduction in growth or crop yield is classified as tolerant. Tolerant crops can be harvested successfully but will leave high residual nematode populations in the soil, which can threaten subsequent susceptible crops.

212. (C) No visible galls on the root system
The standard zero-to-five visual scoring scale is widely used to evaluate root-knot nematode damage. In this rating system, a score of zero represents the healthiest outcome, signifying the complete absence of visible galls or galled tissue on the entire root system. This score indicates a highly resistant, immune, or uninfected plant response.

213. (A) White or yellow adult females attached to the roots
Screening crop germplasm for resistance to cyst nematodes requires a different visual metric than root-knot indexing. Because cyst nematodes do not form prominent galls, researchers evaluate susceptibility by counting the prominent white or yellow adult females attached to the root surface. These visible bodies represent successful nematode maturation and reproduction on the host.

214. (C) Phloxine B immersion for 15-20 minutes
Accurately quantifying root-knot nematode reproduction in resistance trials can be difficult because egg masses are often semi-transparent. Immersing the root systems in a Phloxine B solution for fifteen to twenty minutes is the standard staining technique. The dye selectively colors the gelatinous matrices a bright red, making them highly visible and easily counted against the roots.

215. (A) Rapid, localized death of cells surrounding the invader
The hypersensitive reaction is a powerful, genetically controlled defense mechanism employed by resistant plants against endoparasitic nematodes. Upon invasion, the cells immediately surrounding the nematode undergo rapid, localized programmed cell death. This necrotic barrier deprives the parasite of a functional feeding site, starving the nematode and preventing it from completing its life cycle.

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197. (A) Randomized Block Design (RBD)
Greenhouse benches often have subtle environmental gradients, such as variations in light intensity, temperature, or air circulation. Utilizing a Randomized Block Design for pot trials is highly recommended to account for these spatial variations. Grouping experimental replicates into blocks minimizes the influence of environmental gradients, ensuring that observed differences are due to treatments.

198. (C) Simulate field conditions while controlling population density
Microplot experiments are designed to bridge the gap between artificial greenhouse trials and highly variable field conditions. By using small, physically isolated field plots, researchers can grow crops under natural weather conditions while precisely controlling the initial nematode population density. This setup yields realistic crop loss estimates and damage thresholds for agricultural management.

199. (A) Comparing adjacent plants with contrasting nematode densities
Estimating crop losses in commercial fields can be challenging due to environmental heterogeneity. A paired-plant design addresses this by selecting and comparing adjacent plants within the same row that exhibit contrasting nematode infestation levels. Because these plants share identical soil types and microclimates, differences in their growth and yield are directly attributable to nematode damage.

200. (B) 1, 2, 3, 4, 5
Conducting a nematicide screening trial in greenhouse pots requires a logical, chronological workflow. Pots are first filled with sterile soil mixture, and susceptible seedlings are transplanted. After the plants establish, the standardized nematode inoculum is introduced, followed by the application of the test nematicide treatments. Finally, plants are harvested to assess damage and population dynamics.

201. (B) Yield differences between treated and untreated plots reflect loss.
Utilizing a chemical check or nematicide treatment in field trials is a classic method for estimating crop losses. This approach assumes that the applied chemical successfully suppresses the nematode population without directly affecting plant growth. Consequently, any differences in crop yield between the protected, treated plots and the infested, untreated plots represent the loss caused by nematodes.

202. (C) Root gall index (RGI)
The Root Gall Index is universally recognized as the most direct and reliable visual indicator of root-knot nematode damage. Because Meloidogyne species induce characteristic swelling and gall formation on host roots during feeding, the severity of this galling directly reflects the level of parasitism. Scoring the root system provides a standardized metric for evaluating plant damage.

203. (D) Mortality percentage and egg hatching inhibition over time
Initial laboratory screening of potential nematicidal compounds relies on high-throughput in vitro bioassays. These assays evaluate the efficacy of the test chemical by measuring two primary biological parameters: the percentage of nematode mortality and the inhibition of egg hatching over a standardized time period. This quantitative data helps identify promising candidates for greenhouse trials.

204. (A) Touching the nematode with a pick to check for responses
Determining nematode viability during chemical assays is critical, as many compounds induce temporary paralysis rather than death. To distinguish between a paralyzed and a dead nematode, researchers physically touch the specimen with a fine pick under a stereomicroscope. Truly dead nematodes remain completely unresponsive, whereas paralyzed individuals often exhibit subtle tail or head movements.

205. (B) Dissolving in a solvent (DMSO/acetone) before adding to water
Many synthetic and natural nematicidal compounds are highly hydrophobic and do not dissolve directly in water. To evaluate these chemicals in aqueous bioassays, they must first be dissolved in a small volume of an organic solvent, such as DMSO or acetone. This concentrated solution is then diluted with water to create a stable, homogeneous emulsion.

206. (B) Potato root diffusate (PRD)
Hatching assays for cyst-forming nematodes require specific host-derived chemical signals

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the specimen boundaries, providing exceptional clarity and contrast of internal structures.

132. (D) They should be arranged in a neat row or radially for scanning.
When preparing permanent slides, the arrangement of specimens within the glycerine drop is critical for efficient observation. Arranging multiple nematodes in a neat parallel row or a radial pattern allows the microscopist to scan them systematically. This organized layout prevents specimens from overlapping, simplifies tracking under high magnification, and ensures no individual is missed during counting.

133. (A) Acid fuchsin
Acid fuchsin is the most widely used chemical dye for staining plant-parasitic nematodes inside intact host roots. This acid aniline dye has a strong, selective affinity for the proteinaceous tissues of nematodes, particularly their cuticle and internal organs. When properly applied, it colors the nematodes intensely while leaving the plant cortical cells relatively unstained.

134. (B) NaOCl clearing → Rinse → Acid Fuchsin boiling → Destaining
The traditional Byrd et al. protocol for staining nematodes within plant roots follows a systematic chemical sequence. Roots are first cleared with sodium hypochlorite to bleach pigments and increase permeability. After rinsing, they are heated in an acid fuchsin solution to stain the nematodes, followed by a destaining step in glycerine to clear background plant tissues.

135. (A) To act as a strong bleaching agent to enhance tissue contrast
Plant roots contain natural pigments, starches, and cytoplasmic materials that can obscure nematodes under microscopic viewing. Treating the roots with a dilute solution of sodium hypochlorite acts as a powerful bleaching and clearing agent. This chemical treatment removes pigments and partially digests internal cell contents, creating excellent transparency and enhancing contrast after staining.

136. (D) Deep pink or red
After undergoing the acid fuchsin staining protocol, plant-parasitic nematodes embedded within the root tissues are highly visible. The dye binds strongly to the nematode's protein structures, coloring them a brilliant deep pink or red. This intense coloration contrasts sharply with the cleared, semi-transparent plant cells, allowing for easy location and counting under a stereomicroscope.

137. (B) Cotton blue (Methyl blue)
Cotton blue, also known as methyl blue, is a common alternative dye used in plant nematology laboratories. When a blue coloration of the nematodes is preferred over red, this stain is substituted for acid fuchsin. It selectively binds to fungal chitin and nematode proteins, rendering the specimens a deep blue color against a cleared plant background.

138. (C) To remove background stain while leaving nematodes colored
Boiling roots in staining solutions often results in both the plant tissues and the nematodes absorbing the dye. Transferring the stained roots to acidified glycerine is a critical destaining step. The acid gradually leaches the dye out of the plant cell walls faster than from the nematode bodies, maximizing contrast between the dark red nematodes and clear roots.

139. (D) High toxicity and carcinogenic properties of phenol
Lactophenol was historically a primary mounting and clearing medium in nematology, valued for its excellent optical properties. However, its use has been heavily restricted in modern laboratories due to safety regulations. Phenol is highly toxic, corrosive, and recognized as a potent carcinogen and mutagen. Laboratories have transitioned to safer alternatives, such as lactic acid or glycerine.

140. (A) P-4, Q-3, R-1, S-2
Staining protocols utilize specific chemical components to achieve high-contrast visualization of nematodes in host tissues. Acid fuchsin selectively stains nematodes red, while sodium hypochlorite bleaches the root tissues. Acidified glycerine functions to destain the background plant cells, and Phloxine B is highly effective for coloring the gelatinous egg masses of root-knot nematodes on root surfaces.

141. (B) Stain egg mass gelatinous matrices without staining the roots
Phloxine B is a highly selective red dye used to facilitate the evaluation of root-knot nematode reproduction. When infested root systems are immersed in a Phloxine B solution, the dye

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216. (D) Incubation in a lysis buffer with Proteinase K and heat inactivation
Extracting DNA from a single microscopic nematode requires a highly efficient, minimal-loss protocol. The standard method involves incubating the individual specimen in a specialized lysis buffer containing Proteinase K, which digests cuticular proteins and releases the genomic DNA. This reaction is followed by heat inactivation to destroy the enzyme before subsequent PCR amplification.

217. (B) Humic acids and phenolics that inhibit PCR enzymes
Extracting high-quality total DNA directly from soil samples is a valuable tool for diagnostic monitoring, but is technically challenging. Soils contain abundant organic molecules, particularly humic acids and phenolic compounds, which co-extract with the DNA. These substances act as potent PCR inhibitors, chemically binding to and inactivating polymerase enzymes during amplification.

218. (C) Purification using spin columns with silica or magnetic beads
To ensure successful PCR amplification from soil DNA extracts, researchers must eliminate co-extracted inhibitors. Passing the crude lysate through specialized spin columns containing silica membranes or magnetic beads is highly effective. These matrices selectively bind DNA under specific salt conditions, allowing humic acids and other inhibitors to be washed away before pure DNA is eluted.

219. (D) Exponentially amplify a specific target segment of DNA
The Polymerase Chain Reaction is a revolutionary molecular technique widely used in diagnostic nematology. It operates by utilizing sequence-specific primers and a thermostable DNA polymerase to exponentially amplify a targeted segment of DNA. This process turns undetectable trace amounts of genetic material into abundant copies, allowing for precise species identification.

220. (B) II and III
Molecular identification of nematodes utilizes distinct genomic regions. The Internal Transcribed Spacer region of ribosomal DNA is highly variable between species, not conserved, making it an excellent diagnostic marker. Species-specific primers amplify DNA from only target species, and Restriction Fragment Length Polymorphism analysis uses restriction enzymes to cut DNA at specific sequence motifs for identification.

221. (B) The double-stranded DNA template separates into single strands
The initial step in each PCR cycle is denaturation, which is conducted at high temperatures between ninety-four and ninety-five degrees Celsius. This intense heat disrupts the hydrogen bonds holding the complementary bases together, causing the double-stranded DNA template to separate into single strands. This separation exposes the target sequence for primer binding in the subsequent step.

222. (B) Banding patterns created after digesting DNA with restriction enzymes
Restriction Fragment Length Polymorphism analysis is a reliable molecular tool for identifying nematode species. The method involves digesting PCR-amplified DNA segments with specific restriction enzymes that cut the DNA at precise sequence sites. Comparing the resulting fragment lengths on an agarose gel reveals unique banding patterns that serve as diagnostic fingerprints for different species.

223. (A) Allows for precise quantification of nematode target DNA
Real-time PCR, also known as quantitative PCR, has revolutionized diagnostic nematology. Unlike conventional PCR, which only detects the presence or absence of a target band, real-time PCR monitors the amplification process continuously using fluorescent dyes. This allows researchers to precisely quantify the initial concentration of target DNA, enabling rapid estimation of nematode densities in soil samples.

224. (C) Cytochrome c oxidase subunit I (COI) gene in the mitochondrial DNA
DNA barcoding is a standardized method for rapid species identification using a short, highly diagnostic gene sequence. In animal taxonomy, including many nematode groups, the mitochondrial Cytochrome c oxidase subunit I gene is the primary target. This gene exhibits high inter-specific variation and low intra-specific diversity, making it an ideal marker for distinguishing closely related species.

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complementary carbohydrates on the nematode cuticle, ensuring the bacterium only infects its target host species.

244. (D) Passing the water through ultra-fine sieves to concentrate them
Monitoring irrigation water for plant-parasitic nematodes requires processing large volumes of liquid. Simply using static funnels is inefficient. The standard methodology involves passing the water through a series of ultra-fine sieves, which mechanically capture the nematodes while letting the water pass. The retained organisms are then washed off into a small, concentrated volume for analysis.

245. (A) Vigorously agitated to ensure uniform distribution of nematodes
Nematodes quickly sink in static water due to their density, leading to uneven distribution in suspension. Before drawing a representative aliquot for population estimation, the stock suspension must be vigorously agitated. This uniform mixing ensures that the drawn sample contains a representative concentration, preventing sampling bias and yielding accurate, reproducible population counts in the laboratory.

246. (C) Concentric channels or a gridded matrix to guide scanning
Enumerating microscopic nematodes under a stereomicroscope requires a methodical approach to prevent counting errors. Standard counting dishes are designed with internal structures, such as concentric channels or a gridded matrix on the bottom. These physical guides allow the researcher to scan the suspension systematically, ensuring every nematode is counted once and none are missed.

247. (B) 1.0 ml
The Hawksley counting slide is a specialized diagnostic tool used to standardize the volume of nematode suspensions analyzed under a microscope. It features a precision-engineered chamber designed to hold a fixed volume of exactly 1.0 milliliter. This standardized volume simplifies population calculations, allowing direct extrapolation of nematode counts to the entire stock suspension.

248. (B) 1125
Calculating nematode density requires extrapolating counts from a known aliquot to the total sample. With forty-five nematodes per milliliter in a fifty-milliliter suspension, the total recovered population is twenty-two hundred fifty. Since these were extracted from a two hundred-gram soil sample, dividing by two yields an estimated population density of eleven hundred twenty-five nematodes per one hundred grams.

249. (B) A certified containment facility with strict waste protocols
Processing agricultural samples suspected of harboring regulated quarantine pests, such as Globodera or Meloidogyne enterolobii, poses high biosecurity risks. The extraction must be conducted within a certified containment facility equipped with negative air pressure and strict waste sterilization protocols. This prevents the accidental escape and spread of these destructive pathogens into the local environment.

250. (C) Centrifugal flotation with sucrose or magnesium sulfate
Direct estimation of nematode egg populations in soil is critical for managing cyst and root-knot species. Because eggs are completely non-motile, they cannot be recovered using behavioral methods like the Baermann funnel. Centrifugal flotation using dense sucrose or magnesium sulfate solutions is the only method capable of physically separating and recovering these dormant stages from soil particles.

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251. (D) Damage caused by extreme high temperatures
Soil samples collected for nematode analysis must be kept cool during transit to ensure accurate laboratory results. Exposure to extreme high temperatures inside vehicles or shipping containers is highly detrimental, causing rapid nematode mortality and accelerated tissue decomposition. This heat damage prevents successful extraction, resulting in artificially low counts that do not reflect field density.

252. (A) Multiple cores mixed to form one representative sample
In diagnostic nematology, obtaining a representative sample is critical due to the highly patchy distribution of soil populations. The term composite sampling refers to the process of collecting multiple individual soil cores from across a designated field area and mixing them thoroughly. This combined mixture averages out spatial variations, providing a reliable diagnostic sample.

grain substrate, typically between thirty and forty percent, is critical. Insufficient moisture halts fungal growth, while excess water causes anaerobic compaction and bacterial putrefaction, ruining the batch.

235. (D) Talc powder or vermiculite
Formulating mass-produced biological control agents into stable commercial products requires mixing the active spores with inert carriers. Talc powder and vermiculite are widely used carrier materials for wettable powders and granules. These inert substances provide a dry, stable substrate that protects the spores, prevents clumping, and facilitates easy mixing and application in the field.

236. (A) Colony Forming Units (CFU) per gram of formulated product
The quality and biological potency of a commercial bio-nematicide must be verified before field application. This viability is standardly assessed by determining the number of Colony Forming Units per gram of formulated product. Plating diluted samples on selective agar media allows researchers to count the surviving, active propagules, ensuring the product meets regulatory standards.

237. (B) Destroying a susceptible crop after invasion but before reproduction
The trap crop strategy is an effective cultural management method for suppressing nematode populations. It involves planting a highly susceptible crop that actively attracts and allows nematode invasion into its roots. Crucially, the crop is destroyed or plowed under after invasion but before the nematodes can complete development and reproduce, trapping and killing them.

238. (B) Virulence and pathogenicity during repeated subculturing
In biological control production facilities, maintaining the efficacy of the active organism is critical. The initial pure mother culture must undergo regular bioassays against target nematodes to confirm it has not lost its virulence and pathogenicity. Repeated subculturing on artificial media can lead to genetic drift or attenuation, reducing the bioagent's pest control efficiency.

239. (A) Autoclaving at 121°C and 15 psi
Solid-state fermentation of biocontrol fungi requires a completely sterile substrate to prevent contamination by wild molds and bacteria. Autoclaving the cereal grains at one hundred twenty-one degrees Celsius and fifteen pounds per square inch of pressure is the standard method. This high-pressure steam sterilization destroys all vegetative cells and resilient bacterial endospores before inoculation.

240. (D) Only IV
Classifying host status relies on understanding both nematode reproduction and plant damage. While resistant plants restrict reproduction, tolerant plants support high reproduction without yield loss, and immune plants completely prevent nematode entry or feeding. Conversely, a susceptible plant is characterized by a high reproduction factor and significant yield loss, making the fourth statement incorrect.

241. (D) A soil exhibiting high levels of indigenous natural enemies
A nematode-suppressive soil is a valuable ecological phenomenon where crop damage remains low despite the presence of a virulent pest. This suppression is driven by high levels of indigenous natural enemies, such as nematophagous fungi, parasitic bacteria, and predatory mites, within the soil microbiome. These beneficial organisms actively suppress the pest population below economic damage thresholds.

242. (B) 6 to 12 months
Commercial success of biological nematicides depends heavily on their shelf-life stability. To be commercially viable, a formulated product must retain a minimum viable CFU count for at least six to twelve months under standard room storage conditions. This duration ensures the product remains effective through transit, distribution, and storage before seasonal field application.

243. (B) Biochemical receptor-ligand interactions on the cuticle
The host-finding and infection process of Pasteuria penetrans is highly specialized and host-specific. The attachment of bacterial endospores to the cuticle of moving nematode juveniles relies on precise biochemical receptor-ligand interactions. Specific proteins on the spore surface bind to

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225. (D) 18S, ITS (ITS1 and ITS2), and 28S segments
Ribosomal DNA arrays are highly favored for nematode molecular taxonomy and diagnostics. In addition to mitochondrial genes, researchers extensively target the nuclear ribosomal DNA cluster, which includes the 18S, internal transcribed spacer regions, and the 28S segments. These regions contain a useful mixture of highly conserved and variable sequences, allowing for genus- and species-level identification.

226. (C) Simultaneous amplification of multiple targets in one tube
Multiplex PCR is a highly efficient molecular technique used to streamline diagnostic workflows. By incorporating multiple sets of species-specific primers into a single reaction tube, the assay can simultaneously amplify and detect several different target nematode species in a single run. This saves time, reduces reagent costs, and is highly valuable for routine quarantine screenings.

227. (B) Negatively charged due to its phosphate backbone
Gel electrophoresis separates DNA fragments based on physical size and electrical charge. The molecular structure of DNA includes a repeating phosphate backbone, which carries a net negative charge under standard alkaline buffer conditions. When an electrical field is applied to the agarose gel, the negatively charged DNA molecules naturally migrate towards the positive anode.

228. (D) Pasteuria penetrans
Pasteuria penetrans is a highly specialized biological control agent of agricultural importance. This organism is an obligate, endospore-forming bacterium that parasitizes root-knot nematodes of the genus Meloidogyne. The bacterial endospores attach to the juvenile cuticle in the soil, eventually germinating and proliferating within the developing female, completely preventing egg production and causing nematode death.

229. (A) Requires in vivo production on living host nematodes
Despite its high efficacy as a biocontrol agent, the commercial use of Pasteuria penetrans is limited by production challenges. As an obligate parasite, this bacterium cannot be cultured on standard synthetic agar media in vitro. Its mass production requires in vivo cultivation on living host nematodes inside greenhouse plants, which is labor-intensive and expensive to scale.

230. (C) Eggs and sedentary females
Purpureocillium lilacinum is a highly versatile, soil-dwelling fungus used as a biological nematicide. It primarily targets the immobile life stages of plant-parasitic nematodes, specifically the eggs and sedentary adult females on the root surface. The fungal hyphae penetrate the eggshell or female cuticle, secreting destructive enzymes that digest the internal contents and kill the pest.

231. (A) Cereal grains and agricultural by-products
Mass production of the nematophagous fungus Pochonia chlamydosporia is routinely achieved using solid-state fermentation. The fungus is inoculated onto sterile cereal grains, such as wheat, barley, or rice, or other inexpensive agricultural by-products. These substrates provide both the physical surface and the essential carbohydrates required for abundant mycelial growth and spore production.

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232. (D) It allows better control of environmental parameters for scale-up
Commercial bio-pesticide manufacturers prefer liquid fermentation over solid-state methods for large-scale production. Liquid bioreactors allow for precise, automated control of critical environmental parameters, such as pH, dissolved oxygen levels, temperature, and nutrient concentration. This high level of process control ensures consistent product quality, rapid fungal growth, and efficient scale-up to industrial volumes.

233. (B) Chlamydospore
Pochonia chlamydosporia produces a specialized, thick-walled resting spore known as a chlamydospore. This structure is highly resistant to desiccation, temperature fluctuations, and chemical stress, allowing the fungus to survive adverse soil conditions. The abundance of chlamydospores in commercial formulations ensures a long shelf-life and high viability of the bioagent after field application.

234. (C) Moisture content (typically 30-40%)
During the solid-state mass production of fungi on cereal grains, maintaining the correct physical environment is essential. Monitoring and controlling the moisture content of the

253. (B) Populations stratify based on root and moisture profiles
Plant-parasitic nematodes are closely associated with host root systems, which vary in depth depending on crop type. In deep-rooted perennial orchards, nematode populations often stratify vertically in the soil, following the active root growth and soil moisture profiles. Sampling at multiple depths ensures representative collection of species that inhabit deeper root zones.

254. (B) Clay aggregation traps nematodes in the heavy pellet
Centrifugal flotation is highly effective for sandy soils but is less efficient when processing heavy clay. Fine clay particles easily form tight, stable aggregates that do not break down completely in water. During centrifugation, these clay clumps physically trap and bind the nematodes, dragging them down into the discarded heavy mineral pellet instead of letting them float.

255. (A) Nearly zero nematode recovery due to large apertures
Sieve mesh sizes must match the physical dimensions of the target organisms. If a technician mistakenly uses a coarse twenty-mesh sieve, which has a large aperture of eight hundred fifty micrometers, as the final collection screen, almost all nematodes will wash through and be lost in the waste water, resulting in nearly zero recovery.

256. (C) Filtered seawater to prevent osmotic explosion
Soft-bodied marine and estuarine nematodes are highly adapted to high-salinity environments. If these specimens are placed directly into fixatives prepared with fresh distilled water, the sudden osmotic pressure drop causes water to rush into their bodies, leading to distortion or explosive cellular lysis. Preparing fixatives with filtered seawater maintains osmotic balance, preserving their morphology perfectly.

257. (D) Differences in refractive index between nematode and mountant
Under light microscopy, an optical artifact known as refraction halo can obscure the fine margins of unstained nematodes. This glowing border is fundamentally caused by a significant difference in refractive index between the nematode's physical cuticle and the surrounding liquid mounting medium. Using clear mountants like anhydrous glycerine matches these indices, eliminating the halo and improving resolution.

258. (C) Measurements are taken along curves rather than the midline
Quantitative morphometrics require precise measurement of the nematode body axis. If a researcher measures a highly curved specimen by tracing along the outer or inner margins of the body curves rather than precisely along the central midline, significant geometric errors are introduced. This bias distorts the calculated body length and associated De Man ratios.

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259. (B) Relatively short and stout in appearance
The De Man ratio 'a' is a key indicator of body shape, reflecting the relationship between length and maximum width. While a high value represents a slender, needle-like shape, a calculated 'a' ratio of fifteen is relatively low. This indicates that the nematode specimen is morphologically short and stout, a characteristic of certain sedentary or specialized genera.

260. (A) II, III and IV
Mass producing biological control agents involves distinct microbiological and formulation protocols. While Pasteuria penetrans is an obligate parasite that cannot be grown in liquid media without host nematodes, Purpureocillium lilacinum grows easily on sterile rice grains. Pochonia chlamydosporia forms highly resilient chlamydospores, and liquid fermentation offers superior process control over solid-state methods for commercial scale-up.

261. (A) The introduced nematode caused the observed symptoms
Verifying the causal relationship between a nematode and plant disease requires completing Koch's postulates. Re-isolating the identical nematode species from the experimentally infected host is the final, critical step. This proof confirms that the specific symptoms observed were directly caused by the introduced nematode pathogen, ruling out other environmental or opportunistic biotic factors.

262. (C) Using physical separation and aerosol-barrier tips
In molecular diagnostic laboratories, aerosolized PCR products from previous runs are a major source of false-positive results. Preventing this contamination requires strict management

300. (A) Ensure accurate, reproducible identification/ quantification

Diagnostic nematology requires high precision to support regulatory biosecurity and agricultural management decisions. The ultimate objective of systematically standardizing all sampling, extraction, morphometric, and molecular protocols is to ensure highly accurate, reproducible species identification and population quantification. Standardized methods minimize laboratory error, facilitating reliable comparisons of results across different research facilities worldwide.

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effects on the crop. This ensures that yield differences between plots represent nematode damage.

272. (C) Distilled or tap water
Hatching assays designed to evaluate the efficacy of nematicidal compounds require a reliable baseline comparison. The standard negative control treatment involves incubating the nematode egg masses in pure distilled or tap water. This provides a measure of natural, uninhibited hatching rates, allowing researchers to accurately calculate the percentage of hatching inhibition caused by chemical treatments.

273. (D) Comparative yield of infected vs. uninfected plants
Evaluating host plant tolerance differs fundamentally from measuring resistance, as tolerant varieties do not restrict nematode reproduction. The primary metric used is the comparative yield of infected versus uninfected plants grown under identical environmental conditions. A tolerant variety shows minimal yield suppression under high pest pressure, maintaining stable crop productivity despite infection.

274. (C) $R_f = 10$; Susceptible
Host suitability is determined by calculating the nematode reproduction factor. Dividing the final population of fifty thousand eggs by the initial inoculum of five thousand yields a reproduction factor of exactly ten. Because this R_f value is significantly greater than one, the tomato variety is classified as a susceptible host that supports rapid nematode multiplication.

275. (B) Cycle threshold (C_t or C_q)
Real-time quantitative PCR monitors the accumulation of amplified DNA during the reaction using fluorescent chemistry. The specific cycle at which the fluorescent signal increases exponentially and crosses a defined background threshold level is known as the Cycle threshold, or C_t value. This value is inversely proportional to the logarithm of initial target DNA concentration.

276. (D) NCBI GenBank or BOLD systems
Identifying unknown nematodes through DNA barcoding requires comparing the amplified genetic sequences against reliable reference libraries. Researchers submit their sequence data to comprehensive, global public databases, such as NCBI GenBank or the Barcode of Life Data systems. Matching the query sequence with cataloged species records allows for fast, highly accurate molecular identification.

277. (A) Intense ultraviolet radiation from direct sunlight
Fungal biological control agents, such as Purpureocillium lilacinum, are sensitive to environmental stress after field application. Intense ultraviolet radiation from direct sunlight is highly detrimental to fungal spores. UV light damages fungal DNA and proteins, rapidly reducing spore viability and field efficacy. For this reason, applications are recommended during late afternoon or cloudy conditions.

278. (C) Pseudocoelomates
In animal systematics, nematodes possess a unique anatomical body plan that defines their taxonomic grouping. They are classified based on their body cavity as pseudocoelomates. Their internal body cavity, containing fluid under high hydrostatic pressure, is not completely lined with mesoderm tissue, distinguishing them from acoelomate flatworms and coelomate annelids.

279. (A) Centrifugal flotation with sucrose
Ecological studies require complete population assessments that account for both live and dead soil nematodes. While the Baermann funnel only recovers active individuals, pairing it with centrifugal flotation using sucrose provides a complete count. Centrifugal flotation relies strictly on density and buoyancy, successfully recovering non-motile, dead, and sluggish specimens that the funnel misses.

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280. (D) Allow heavy particles to slide into the bottom
Cobb's decanting apparatus includes several specialized design features to optimize physical separation. The sieving basins are engineered with a sloping side, which allows heavy mineral soil particles to slide smoothly to the bottom of the vessel during washing. This design prevents sand from remaining suspended, ensuring that only lighter nematodes are decanted.

281. (B) Stoma modified into a protrusible hollow stylet
Distinguishing plant-parasitic Meloidogyne second-stage juveniles from free-living

protocols, including physical separation of pre-PCR and post-PCR workspaces. Researchers must also use aerosol-barrier pipette tips and dedicated equipment to prevent DNA amplicons from entering new reaction tubes.

263. (A) The DNA of M. incognita is present in the extracted sample.
Species-specific PCR assays utilize primers designed to bind exclusively to unique genomic sequences of a target pest. During gel electrophoresis, the appearance of an amplification band of the expected diagnostic size confirms a successful reaction. This visual band indicates that the target DNA of Meloidogyne incognita was present in the initial extracted sample.

264. (D) Polymerase Chain Reaction (PCR)
Isolating genomic DNA from a single microscopic nematode yields extremely small quantities of template material, often below detection thresholds of standard assays. The Polymerase Chain Reaction is highly suited for this work due to its sensitivity. PCR exponentially amplifies target DNA sequences, turning a single copy of a gene into billions of detectable fragments.

265. (B) They exist in repeated tandem copies, increasing PCR success
Designing molecular assays for single nematodes requires targeting genes that are easy to amplify. Ribosomal DNA arrays are highly favored because they exist as multi-copy gene families arranged in tandem repeats within the genome. This high copy number significantly increases the concentration of target template, enhancing PCR amplification success from tiny DNA extracts.

266. (C) Basic dyes binding to acidic or lignified components
Staining histopathological sections of roots with Safranin and Fast Green highlights the physical location of parasites. Safranin is a basic dye that binds specifically to acidic molecules, lignified cell walls, and the proteinaceous components of the nematode cuticle. This chemical affinity colors the invading nematode a brilliant red, contrasting sharply with the green-stained cellulose of healthy cortical cells.

267. (D) Allow uniform and rapid fixative/medium penetration
Preparing plant tissues for histopathological sectioning requires fast, uniform chemical preservation. Cutting root samples into small segments of five to ten millimeters is critical. This physical reduction allows the chemical fixatives, dehydrating alcohols, and paraffin embedding wax to rapidly penetrate the dense root tissues, ensuring complete cellular preservation and preventing internal decay.

268. (A) Bacterivory (feeding on bacteria)
Caenorhabditis elegans is a non-parasitic, free-living soil nematode with a highly specialized feeding habit. Its primary nutritional mode is bacterivory, meaning it feeds exclusively by ingesting and digesting bacterial cells. In nature and laboratory cultures, the nematode utilizes its specialized pharynx to pump suspended bacteria into its gut, serving as a valuable model organism.

269. (B) Inadequate surface-sterilization of the nematode inoculum
Monoxenic carrot disc cultures require sterile conditions to prevent competitive microbial growth. If massive fungal contamination develops within two weeks of inoculation, the protocol failed. This issue is typically caused by inadequate surface-sterilization of the initial nematode inoculum. Any surviving fungal spores introduced with the nematodes will multiply rapidly on the rich carrot tissue.

270. (B) Release of virulent, toxin-producing symbiotic bacteria
Entomopathogenic nematodes kill their insect hosts with exceptional speed, often within forty-eight hours of infection. This rapid mortality is not caused by physical damage from the nematodes themselves. Instead, it is due directly to the release of virulent, toxin-producing symbiotic bacteria into the insect's hemolymph, which rapidly multiply and cause lethal septicemia.

271. (A) Targets nematodes without stimulating direct plant growth
Utilizing a paired-plot design with a chemical treatment to estimate crop losses depends on a key pharmacological assumption. The applied nematicide must target and suppress the plant-parasitic nematodes without exerting any direct physiological growth-stimulating or phytotoxic

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valuable for high-throughput screening trials and sensitive physiological research.

291. (B) Migrate from cadavers to moist environments for new hosts
The extraction of entomopathogenic infective juveniles using White traps is highly efficient because it exploits a specific biological behavior. As resources deplete within the decaying insect host, the newly developed third-stage juveniles are programmed to exit. The trap leverages their natural instinct to migrate away from the cadaver into surrounding moist environments to find new hosts.

292. (D) Observed reproduction differences are due to host genetics
Evaluating host plant resistance requires eliminating confounding variables. In greenhouse pot trials, standardizing pot size, soil mixture, watering regimes, and environmental conditions ensures a uniform growth habitat. This control minimizes environmental influences on nematode reproduction, guaranteeing that any observed differences in population growth between varieties are due strictly to host plant genetics.

293. (A) Prolonged mist chamber extraction (mistifier)
Banana roots are often tough and contain high concentrations of latex and phenolic compounds that can inhibit nematode migration in static systems. For extracting active Radopholus similis from chopped banana roots, the mist chamber technique is highly recommended. The continuous water mist washes away toxic leachates while keeping tissues aerated, maximizing nematode exit.

294. (C) A nematostat
Evaluating chemical efficacy requires distinguishing between lethal and inhibitory effects. A compound that temporarily paralyzes or prevents the movement of nematodes without causing mortality, allowing them to recover completely once placed in fresh water, is classified as a nematostat. These substances suppress nematode activity temporarily rather than acting as true nematicides.

295. (A) A lysis buffer containing SDS and Proteinase K
DNA extraction protocols require breaking down the complex cellular barriers of the nematode. A lysis buffer formulated with sodium dodecyl sulfate and Proteinase K is standardly used. The detergent SDS solubilizes the lipid membranes, while the enzyme Proteinase K digests the structural proteins of the cuticle, releasing the genomic DNA into solution.

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296. (D) Identification is possible from eggs, juveniles, or males
Regulatory and quarantine screenings are often complicated by the absence of diagnostic adult females in intercepted samples. A major benefit of DNA barcoding is that identification is completely independent of the specimen's life stage or sex. Researchers can achieve precise species-level identification using individual eggs, damaged juveniles, or morphologically non-descript males.

297. (B) Conidia (spores)
The commercial viability and shelf-life stability of Purpureocillium lilacinum formulations depend on the physical structure of the propagules. While vegetative mycelia are fragile and die quickly, the fungus produces asexual conidia that are highly resilient. Mass production must optimize environmental conditions to maximize the yield of these durable spores for formulation.

298. (C) Impeding infective juvenile motility via spore coating
Pasteuria penetrans is an effective biological control agent that attacks root-knot nematodes through two distinct mechanisms. In addition to obligate parasitism of the developing female inside the root, the bacterium suppresses populations in the soil. High numbers of endospores physically coat the juvenile cuticle, significantly impeding their motility and reducing their ability to locate and invade host roots.

299. (D) The initial density of nematodes introduced per unit
In experimental plant pathology, researchers must standardize the severity of the pathogen challenge. The term inoculum pressure refers to the initial density of nematodes or eggs introduced per unit of soil or plant system. Manipulating this parameter is essential for determining damage thresholds, estimating crop losses, and evaluating the resistance limits of different plant varieties.

bacterivorous nematodes under stereomicroscopy requires identifying key feeding structures. Plant-parasitic species possess a specialized stoma modified into a sharp, protrusible hollow stylet used to pierce plant cell walls. This anatomical feature is completely absent in bacterivorous species, which have open, unarmed mouth cavities.

282. (C) 60-mesh (250 μm)
Processing soil samples for cyst extraction using the Fenwick can requires selecting the correct sieve sizes. The floating debris and mature cysts that wash over the sloping collar are typically captured on a sixty-mesh sieve, which has an aperture size of two hundred fifty micrometers. This screen retains the cysts while letting fine silt pass.

283. (D) Ethanol is immiscible with the non-polar paraffin wax
During histopathological preparation, dehydrated root tissues must transition from alcohol to embedding wax. However, ethanol is highly polar and completely immiscible with non-polar paraffin wax. Replacing the ethanol with a clearing agent like xylene is crucial, as xylene is fully miscible with both substances, allowing the wax to successfully infiltrate the tissues.

284. (A) The annular diaphragm (phase annulus)
Phase-contrast microscopy enhances contrast in transparent nematode specimens by manipulating light waves. The phase plate, located within the objective lens, works in close optical alignment with a corresponding annular diaphragm, or phase annulus, in the substage condenser. This combination splits light into direct and diffracted paths, translating phase shifts into visible intensity differences.

285. (B) The residual water will boil and destroy the ultrastructure.
Transmission electron microscopes operate under high vacuum conditions that are incompatible with liquid water. If a wet nematode specimen is placed inside the chamber without complete dehydration, the sudden pressure drop causes the residual water to boil instantly. This rapid evaporation physically tears and destroys the cellular membranes, ruining the specimen's internal ultrastructure.

286. (B) Alpha taxonomy (morphological taxonomy)
Systematic identification in nematology has historically relied on physical traits. Identifying an unknown specimen by combining precise morphometric ratios with diagnostic morphological characters constitutes classical Alpha taxonomy. This morphology-based classification remains the foundational system for describing new species, and is increasingly supported by modern molecular diagnostics in reference laboratories.

287. (A) Formalin (formaldehyde)
Preparing Triethanolamine Formalin fixative requires handling hazardous chemicals with strict safety precautions. Formalin, which releases highly toxic formaldehyde gas, possesses a strong, pungent odor and is a recognized respiratory irritant and carcinogen. It must be measured and mixed exclusively within a functional laboratory fume hood to prevent inhalation exposure.

288. (C) Can be easily reheated to remelt and reposition
The wax-ring mounting method is highly favored for slide preparation due to its versatility. A major advantage of this technique is that the solid paraffin wax seal can be easily reheated on a hotplate. This remelts the wax, allowing the researcher to safely adjust the coverslip, reposition the specimen, or recover the nematodes without damage.

289. (D) Lower the pH to enhance dye binding to proteins
Preparing the staining solution for root analysis requires careful chemical balancing. Glacial acetic acid is added to the acid fuchsin mixture to lower the pH of the solution. This acidic environment protonates the protein molecules within the nematode's body, significantly enhancing the binding of the dye and yielding intense, high-contrast staining of the specimens.

290. (C) It allows year-round production of pure inoculum
Rearing plant-parasitic nematodes in monoxenic in vitro systems offers significant advantages over maintaining colonies in greenhouse pots. It eliminates environmental variables, soil-borne contaminants, and seasonal influences, allowing for the year-round production of pure, sterile inoculum. This consistent supply is highly

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CHAPTER 04
Nematode Ecology

2019

1. Which of the following best defines the primary scope of nematode ecology within the soil ecosystem?
(A) The taxonomic classification of nematodes based strictly on molecular and phylogenetic markers
(B) The study of nematode interactions with their biotic and abiotic environment
(C) The chemical synthesis of modern nematicides for broad agricultural pest control
(D) The physiological mapping of the nematode nervous system in isolated laboratory settings

2004

2. Among trophic categories, which nematode group plays a primary role in regulating bacterial populations and nitrogen mineralization?
(A) Fungivores
(B) Herbivores
(C) Predators
(D) Bacterivores

2001

3. What defines a sedentary endoparasitic nematode?
(A) It enters the root, establishes a specialized feeding site, and remains immobile
(B) It feeds externally on root hairs without entering the plant tissue throughout its life
(C) It moves continually through root cortical tissues causing significant cellular necrosis
(D) It feeds partially embedded in the root while retaining full mobility across all stages

2025

4. In which soil horizon are plant-parasitic nematodes typically most concentrated?
(A) O horizon
(B) B horizon
(C) A horizon (rhizosphere)
(D) C horizon

2010

5. Active nematode locomotion in soil pores is most dependent on which physical parameter?
(A) The thickness of the water film surrounding soil particles
(B) Soil temperature extremes consistently above 40 degrees Celsius
(C) The exact atmospheric carbon dioxide concentration in the canopy
(D) The absolute mineral composition of soil quartz and feldspar

NODIA

2012

6. Which of the following is considered a primary mechanism for the passive, long-distance dispersal of nematodes?
(A) Directed sinusoidal movement through the soil matrix
(B) Thermotactic orientation toward host root systems
(C) Chemotactic migration along nutrient concentration gradients
(D) Transport via irrigation water or moving surface water

2007

7. The evolution of a specialized stylet in plant-parasitic nematodes is an adaptation primarily for:
(A) Mating and reproductive behavior during the adult stage
(B) Penetrating host cell walls and withdrawing nutrients
(C) Defending against aggressive nematophagous fungal species
(D) Navigating through dry soil pores during moisture stress

2025

8. The physiological state in which nematodes survive extreme desiccation by entering a reversible state of suspended animation is termed:
(A) Cryobiosis
(B) Anoxybiosis
(C) Anhydrobiosis
(D) Osmobiosis

(B) I and III
(C) II and III
(D) I, II and III

2025

91. Seasonal fluctuations in nematode populations in temperate regions are most strongly correlated with:
(A) Photoperiodic changes affecting moonlight intensity
(B) Temperature variations and host plant growth cycles
(C) The global migration of birds
(D) Changes in soil mineral content over the season

2009

92. The phenomenon where the per capita growth rate of a population decreases as the population density falls below a certain threshold, often making it difficult to find mates, is known as:
(A) Carrying capacity limitation
(B) The Allee effect
(C) Density-independent mortality
(D) Competitive exclusion

2024

93. What is the effect of extremely fine soil texture (e.g., heavy clay) on the movement of a large nematode like Xiphinema?
(A) Movement is restricted due to small pore neck diameters
(B) Movement is greatly enhanced due to water retention
(C) Texture has no effect; only moisture matters
(D) It induces immediate anhydrobiosis

2008

94. The intrinsic rate of natural increase (r_m) is highest for which category of nematodes?
(A) Dorylaimid persisters
(B) Sedentary endoparasites
(C) Opportunistic bacterivores (c-p 1)
(D) Large predators

2011

95. A "dauer" juvenile stage is ecologically significant because it is:
(A) The primary reproductive stage
(B) The only stage that feeds on plant roots
(C) The stage responsible for gall formation
(D) An arrested survival stage adapted for dispersal

2019

96. Which factor is considered a key density-independent regulator of soil nematode populations?
(A) Parasitism by Pasteuria penetrans
(B) Competition for root feeding sites
(C) Tillage and mechanical soil disruption
(D) Predation by Mononchids

2023

97. The concept of concomitant infection implies that:
(A) A nematode and a fungus form a mutualistic symbiosis
(B) Two or more nematode species infect the same host simultaneously
(C) Only one nematode species can exist in a field at any time
(D) Nematodes infect roots only when bacteria are absent

2004

98. Oversummering in hot, arid climates often requires nematodes to:
(A) Increase their metabolic rate drastically
(B) Reproduce exclusively on soil surface litter
(C) Switch to a diet of dry sand
(D) Enter anhydrobiosis or seek deeper soil layers

2004

99. The "Tolerance Limit" (T) is practically useful for farmers because it helps determine:
(A) Economic justification for nematicide application
(B) The exact day to harvest
(C) The genetic composition of the nematode
(D) The volume of irrigation water needed

2004

100. Consider the following statements about nematode reproduction:
I. Hermaphroditic nematodes produce both sperm and oocytes.
II. Amphimixis requires males and females to mate.
III. Parthenogenetic species require environmental stress to produce males for reproduction.
IV. Most root-knot nematodes reproduce via obligate amphimixis.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I, II and III
(C) III and IV
(D) I, III and IV

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(D) Protect viable eggs during unfavorable environments

2024

19. The logistic model of nematode population growth differs from the exponential model by incorporating:
(A) A carrying capacity (K) that limits maximum population size
(B) Constant and unlimited resources for every individual
(C) Zero mortality rates regardless of the population density
(D) An immediate crash to zero after the first generation

2024

20. Consider the following statements about the Seinhorst model:
I. It relates initial nematode density to relative crop yield.
II. It assumes yield is unaffected until a tolerance limit is reached.
III. It applies only to bacterivorous nematodes.
IV. It uses an exponential decay curve to model crop damage.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2007

21. The Economic Threshold Level (ETL) is defined as the nematode density at which:
(A) Control measures should be initiated to prevent reaching the EIL
(B) Crop yield is reduced to zero due to extreme parasitism
(C) The cost of control exceeds the market value of the crop
(D) Nematodes first colonize the surface of the host root

2004

22. In the colonizer-persister (c-p) scale, nematodes with a c-p value of 1 are typically:
(A) Long-lived predators highly sensitive to environmental disturbance
(B) Sedentary endoparasites causing significant root galls on hosts
(C) Obligate entomopathogenic nematodes used in biological control
(D) Short-lived, opportunistic bacterivores reproducing rapidly

2025

23. A decrease in the Maturity Index (MI) of a soil nematode community generally indicates:
(A) A highly stable, undisturbed soil ecosystem
(B) An increase in environmental disturbance or stress
(C) Complete eradication of plant-parasitic nematodes
(D) A transition to climax vegetation and high stability

2001

24. Which index of the soil food web diagnostics indicates the influx of primary resources into the system?
(A) Channel Index
(B) Structure Index
(C) Enrichment Index
(D) Maturity Index

2003

25. Match the following diversity indices with their primary focus:
List I: (Diversity Indices)
P. Shannon-Weaver Index
Q. Simpson's Index
R. Species Richness
S. Evenness
List II: (Primary Focus)
1. Probability that two randomly selected individuals belong to the same species
2. The total count of different species in a community
3. The relative abundance of different species
4. Information-theoretic measure combining richness and abundance
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2003

26. The conceptual framework of nematode ecology most strongly relies on understanding which flow?
(A) Carbon and energy flow through soil micro-food webs
(B) Synthetic fertilizer movement through primary xylem
(C) Electromagnetic fields generated by soil minerals
(D) Atmospheric ozone degradation in the stratosphere

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2017

27. Omnivorous soil nematodes primarily belong to which taxonomic order?
(A) Rhabditida
(B) Dorylaimida
(C) Tylenchida
(D) Aphelenchida

2009

28. Which of the following is a classic example of a migratory endoparasitic nematode?
(A) Meloidogyne incognita
(B) Pratylenchus penetrans
(C) Heterodera avenae
(D) Xiphinema index

2003

29. The vertical distribution of nematodes in a soil profile usually mirrors the distribution of:
(A) Host plant root mass and organic matter
(B) Soil bedrock fragments in the C horizon
(C) Surface atmospheric pressure changes
(D) Total soil clay content exclusively

2007

30. Consider the following statements on nematode biomechanics:
I. Nematode locomotion requires alternating contractions of longitudinal muscles.
II. Nematodes possess well-developed circular muscles for movement.
III. The hydrostatic skeleton provides turgor pressure for movement.
IV. Movement efficiency is heavily dependent on soil pore diameter.
V. Water films must be significantly thicker than the nematode's diameter for optimal movement.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II and V
(C) III and IV
(D) I and IV

2022

31. Seed-borne dispersal is a significant epidemiological factor for which nematode?
(A) Radopholus similis
(B) Rotylenchulus reniformis
(C) Trichodorus spp.
(D) Anguina tritici

2013

32. The development of an enlarged, swollen female body in sedentary nematodes is an adaptation primarily for:
(A) Evading soil predators in the rhizosphere
(B) Enhancing active migration in deep soil
(C) Accommodating massive egg production
(D) Improving oxygen diffusion across the cuticle

2019

33. The state of cryobiosis in nematodes is triggered by:
(A) High salinity levels
(B) Freezing temperatures
(C) Absolute oxygen deprivation
(D) Extreme heat

2007

34. A life-history strategy involving synchronized hatching in response to host exudates ensures that:
(A) Nematodes emerge when food resources are unavailable
(B) The population immediately undergoes anhydrobiosis
(C) Nematodes permanently avoid all chemical gradients
(D) Infective juveniles emerge during active host growth

2019

35. Arrange the following soil particles in order of increasing pore space size they create, which affects nematode migration:
I. Fine clay
II. Coarse sand
III. Silt
(A) I, II, III
(B) III, I, II
(C) I, III, II
(D) II, III, I

2008

36. At the permanent wilting point, the water potential in the soil becomes too low, causing nematodes to:
(A) Increase their feeding rate exponentially
(B) Transition from obligate parasitism to free-living forms
(C) Suffer severe osmotic stress and limit movement
(D) Molt multiple times within a single day

2018

37. Which statement correctly describes the thermal optimum for a plant-parasitic nematode?

NODIA

(A) It is the temperature range where reproduction and development are maximized
(B) It is universally fixed at exactly 25 degrees Celsius for all species
(C) It represents the threshold below which immediate mortality occurs
(D) It is only relevant during the egg stage

2009

38. Soil pH primarily influences nematode populations through:
(A) Direct instantaneous lethality at pH 6.5
(B) Transforming their basic DNA structure
(C) Changing the nematode's trophic classification
(D) Altering mineral solubility and microbial activity

2025

39. The process by which a nematode directs its movement along a concentration gradient of host plant root exudates is known as:
(A) Thigmotaxis
(B) Chemotaxis
(C) Galvanotaxis
(D) Phototaxis

2019

40. Determine the correct sequence of events when Pasteuria penetrans infects a nematode:
I. Proliferation of bacteria inside the nematode body
II. Attachment of endospores to the nematode cuticle
III. Release of new endospores into the soil
IV. Penetration of the infection tube into the pseudocoelom
(A) II, IV, I, III
(B) I, II, III, IV
(C) IV, II, I, III
(D) II, I, IV, III

2015

41. Concomitant infection of roots by Meloidogyne and Pratylenchus often leads to:
(A) Enhanced gall formation by Meloidogyne without interference
(B) Complete disappearance of the host plant within days
(C) Fusion of both species into a hybrid organism
(D) Antagonistic interactions reducing feeding sites

2004

42. In a nematode life table, the term "l_x" represents:
(A) The age-specific survival rate or proportion surviving to age x
(B) The number of eggs laid per female
(C) The maximum theoretical population size
(D) The intrinsic rate of natural increase

2013

43. Overwintering in many nematode species is facilitated by:
(A) Continuous active feeding on dormant roots
(B) The formation of dauer larvae or environmentally resistant eggs
(C) Rapid consecutive molts
(D) Complete depletion of lipid reserves

2023

44. In the mathematical model for exponential growth ($\frac{dN}{dt} = rN$), the term "r" signifies:
(A) Carrying capacity
(B) Intrinsic rate of increase
(C) Initial population size
(D) Time

2018

45. Read the following assertion (A) and reason (R) and select the correct option:
Assertion (A): The Tolerance Limit (T) in the Seinhorst model is the nematode density up to which no measurable crop yield loss occurs.
Reason (R): Plants possess compensatory growth mechanisms that can offset minor nematode damage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

46. The Economic Injury Level (EIL) is always:
(A) Lower than the Economic Threshold Level (ETL)
(B) Equal to the Tolerance Limit (T)
(C) Higher than or equal to the Economic Threshold Level (ETL)
(D) Independent of crop market value

2004

47. In the c-p classification, dorylaimid nematodes typically score high (c-p 4 or 5) because they:
(A) Have short life cycles and high reproductive rates
(B) Thrive exclusively in heavily polluted environments
(C) Feed only on bacteria

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(D) Are highly sensitive to stress and have long generation times

2015

48. The Plant Parasitic Index (PPI) is calculated similarly to the Maturity Index (MI) but is based exclusively on:
(A) Predatory nematodes
(B) Free-living bacterivores
(C) Plant-parasitic nematode families
(D) Soil microarthropods

2011

49. The Channel Index in soil food web analysis provides information about:
(A) The precise ratio of sand to silt in the soil
(B) The balance between bacterial and fungal decomposition pathways
(C) The total biomass of the host plant
(D) The moisture channel depth in agricultural fields

2014

50. Consider the following statements regarding biodiversity indices:
I. Species richness is simply the count of different species present.
II. Evenness measures how equally abundant the species are within the community.
III. Shannon-Weaver index completely ignores species evenness.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2010

51. The primary ecological role of predatory nematodes like Mononchus in the soil is:
(A) Top-down regulation of other nematode populations
(B) Nitrogen fixation
(C) Primary production via photosynthesis
(D) Decomposition of complex lignin

2017

52. Which physiological mechanism best explains anhydrobiosis in nematodes?
(A) Rapid multiplication of mitochondria
(B) Excretion of all body lipids
(C) Massive accumulation of trehalose to stabilize cell membranes
(D) Transformation of the stylet into a water-absorbing tube

2013

53. Migratory ectoparasites typically feed on:
(A) The outermost epidermal cells and root hairs while remaining outside the root
(B) Deep vascular tissues of the stem
(C) The apical meristem of the shoot
(D) Intracellular components of the leaf mesophyll

2003

54. The spatial distribution of nematodes in an agricultural field is most commonly:
(A) Perfectly uniform
(B) Randomly scattered without any pattern
(C) Exclusively linear along the soil surface
(D) Aggregated or patchy

2014

55. The movement threshold of nematodes in soil is most restricted when soil pore diameters are:
(A) Significantly larger than the nematode's length
(B) Smaller than the nematode's body diameter
(C) Exactly equal to the nematode's length
(D) Filled entirely with air rather than water

NODIA

2021

56. Anthropogenic dispersal of nematodes is most frequently caused by:
(A) High-altitude wind currents
(B) Ocean currents
(C) Movement of contaminated soil on farm machinery and tools
(D) Migratory bird patterns

2007

57. The extensive development of esophageal glands in sedentary endoparasites is primarily associated with:
(A) Digestion of internal lipid reserves
(B) Production of alarm pheromones
(C) Detoxification of soil nematicides
(D) Synthesis of effectors injected into host cells

2007

58. Hermaphroditism in certain nematodes, such as Caenorhabditis elegans, allows for:
(A) Self-fertilization, ensuring reproduction even when isolated
(B) Outcrossing with different genera
(C) Complete avoidance of genetic mutations
(D) Development of wings for aerial dispersal

2019

59. The gelatinous matrix secreted by root-knot nematode females primarily serves to:
(A) Facilitate soil movement

(B) Protect the eggs from desiccation and microbial attack
(C) Attract male nematodes from long distances
(D) Solubilize soil phosphorus

2009

60. Consider the following statements about soil environment:
I. Nematode activity peaks at field capacity.
II. O2 consumption is independent of temperature.
III. Compaction decreases soil pore space, restricting nematode movement.
IV. Sandy soils exhibit a lower water holding capacity than clay soils.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I, II and III

2018

61. Which of the following best describes the ecological niche of an omnivorous soil nematode?
(A) Feeds on a diverse diet that may include bacteria, algae, fungi, and other microorganisms
(B) Feeds exclusively on living plant roots
(C) Acts as an obligate parasite of fungi
(D) Relies entirely on dissolved atmospheric nitrogen

2006

62. Which life stage of the root-knot nematode (Meloidogyne spp.) is primarily responsible for dispersal and host infection?
(A) Egg
(B) Fourth-stage juvenile (J4)
(C) Second-stage juvenile (J2)
(D) Adult female

2016

63. Osmobiosis is a survival strategy activated in response to:
(A) Extreme low temperatures
(B) Complete lack of oxygen
(C) High concentrations of carbon dioxide
(D) High solute concentrations in the surrounding soil solution

2003

64. A semi-endoparasitic nematode is characterized by:
(A) Remaining entirely outside the root tissue while feeding
(B) Entering the root completely and remaining fully mobile
(C) Having its anterior portion embedded in host tissue
(D) Feeding only on the aerial parts of the plant

2010

65. Match the following nematode adaptations with their corresponding ecological functions:
List I: (Nematode Adaptations)
P. Dauer larva formation
Q. Stylet modification
R. Cuticular annulation
S. Synchronized hatching
List II: (Ecological Functions)
1. Efficient host cell penetration
2. Flexibility and movement in soil
3. Emergence matched to host presence
4. Survival during severe environmental stress
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-3, R-4, S-1

2024

66. The geographical distribution of major nematode biomes is primarily dictated by:
(A) Soil pH levels globally
(B) The phase of the moon
(C) Industrial pollution indices
(D) Climate patterns and host plant distribution

2008

67. Which of the following factors exerts a negative, density-dependent effect on a nematode population?
(A) Intra-specific competition for limited root resources
(B) Unusual frost events
(C) Application of a broad-spectrum nematicide
(D) Sudden flooding of the field

2004

68. The concept of "carrying capacity" (K) in nematode ecology refers to:
(A) The maximum number of eggs a single female can produce
(B) The weight of soil a nematode can displace
(C) The maximum sustainable population size in an environment
(D) The rate of nematode dispersal via water

2011

69. In the Seinhorst model, what does the variable 'm' represent?
(A) The minimum relative yield obtained at maximum nematode density

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2025

9. Parthenogenesis in certain plant-parasitic nematodes provides which major ecological advantage?
(A) Increased genetic diversity through chromosomal recombination
(B) Enhanced resistance to diverse chemical nematicide classes
(C) The ability to feed on a significantly wider host range
(D) Rapid population build-up in the absence of mating males

2011

10. Consider the following statements regarding soil properties and nematodes:
I. Coarse-textured sandy soils typically favor the movement of large nematodes.
II. Clay soils often restrict nematode movement due to small pore spaces.
III. Soil structure has no significant effect on nematode habitability.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2010

11. At which soil moisture level is nematode activity typically optimal?
(A) Saturation point
(B) Field capacity
(C) Permanent wilting point
(D) Oven-dry state

2024

12. How do temperature extremes generally affect nematode embryogenesis?
(A) They accelerate the hatching process indefinitely
(B) They induce a state of dormancy or diapause
(C) They trigger immediate molting into adults
(D) They cause a shift from herbivory to bacterivory

2022

13. High carbon dioxide concentration and low oxygen availability in waterlogged soils typically lead to:
(A) Reduced survival and activity of plant-parasitic nematodes
(B) Increased reproductive rates in strictly aerobic nematodes
(C) Rapid migration towards the anaerobic saturated zone
(D) Enhanced stylet development for improved host penetration

2004

14. Which component of root exudates often serves as a specific hatching factor for cyst nematodes?
(A) Complex lignin polymers found in cell walls
(B) Simple soil humic acids from organic matter
(C) Specific host-derived allelochemical compounds
(D) Inorganic nitrate ions found in fertilizers

2024

15. Read the following assertion (A) and reason (R) and select the correct option:
Assertion (A): Nematophagous fungi can actively trap and digest soil nematodes.
Reason (R): These fungi form specialized structures like constricting rings or adhesive nets in response to nematode presence.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2019

16. Interspecific competition among plant-parasitic nematodes on the same host typically results in:
(A) A mutualistic increase in both species populations
(B) The synthesis of shared specialized feeding sites
(C) Niche partitioning or competitive exclusion
(D) Complete host plant immunity to all infection

2008

17. Which parameter is a vital component of a nematode life table?
(A) Nematicide application rate in a given season
(B) Age-specific mortality and natality rates
(C) Soil particle size distribution in the field
(D) Atmospheric nitrogen concentration in the soil

2001

18. Survival structures like cysts in Globodera species primarily function to:
(A) Facilitate rapid active movement in compacted soil
(B) Attract predatory microarthropods to the root zone
(C) Increase oxygen consumption during the summer heat

(B) II, III, I
(C) I, II, III
(D) III, II, I

2007

81. The term "natality" in a nematode life table refers to:
(A) The death rate of adults
(B) The birth rate or production of new offspring
(C) The migration rate out of the root zone
(D) The rate of natural predation

2021

82. Which environmental factor acts as a primary attractant directing J2s of root-knot nematodes toward the elongation zone of roots?
(A) A gradient of ultraviolet light
(B) Uniform soil temperature
(C) Pure atmospheric nitrogen
(D) A gradient of CO2 and root exudates

2019

83. The physical mechanism of root cell penetration by a nematode stylet involves:
(A) A combination of mechanical thrusting and enzymatic secretions
(B) Only chemical enzymatic degradation of the cell wall
(C) Only mechanical thrusting generated by body musculature
(D) Phagocytosis by the plant cell

2024

84. Which trophic group of nematodes is characterized by possessing a wide, unarmed stoma, often cup-shaped or cylindrical, used to ingest microbes?
(A) Plant-parasitic nematodes
(B) Predatory nematodes
(C) Bacterivorous nematodes
(D) Omnivorous nematodes

2009

85. Read the following assertion (A) and reason (R) and select the correct option:
Assertion (A): The use of the Shannon-Weaver index alone can sometimes be misleading in nematode ecology.
Reason (R): It combines both species richness and evenness into a single value, obscuring which of the two factors is driving changes in diversity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

2011

86. Which equation properly represents the Seinhorst relative yield (y) model for initial nematode density (P) greater than the tolerance limit (T)?
(A) $y = P \times T$
(B) $y = m \times z^{T}$
(C) $y = (1 - m) + z^{\{P\}}$
(D) $y = m + (1 - m)z^{\{P - T\}}$

2025

87. An increase in the Structural Index (SI) of a soil food web typically indicates:
(A) High levels of chemical toxicity in the soil
(B) Recovery of complexity and presence of persister nematodes
(C) A bacterial bloom following fertilizer application
(D) Total eradication of predatory mites

2005

88. How do most plant-parasitic nematodes navigate the tortuous paths of soil pore spaces?
(A) By swimming in an amoeboid fashion
(B) By utilizing flagella extending from their tail
(C) By undulatory propulsion against soil particles
(D) By expanding and contracting like an earthworm

2019

89. Which characteristic is a primary identifier of a predatory nematode like Discolaimus?
(A) A tiny, delicate stylet for piercing fungal hyphae
(B) Complete lack of a digestive tract
(C) An obligate sedentary lifestyle inside plant roots
(D) A large tooth or a heavily armed buccal cavity

2025

90. Consider the following statements about host finding:
I. Repellants in root exudates can deter incompatible nematodes.
II. Nematodes locate roots randomly without chemical cues.
III. Carbon dioxide gradients assist in long-distance orientation.
Which of the above statement(s) is/are correct?
(A) I and II

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(B) The tolerance limit
(C) The multiplication rate
(D) The initial nematode density

2016

70. Consider the following statements concerning nematode community analysis:
I. Bacterivores typically possess high c-p values.
II. The Enrichment Index (EI) increases with the input of fresh organic matter.
III. Persister nematodes indicate a highly disturbed soil environment.
IV. The Structure Index (SI) correlates with the complexity of the soil food web.
V. A high Maturity Index (MI) generally reflects an undisturbed ecosystem.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) II, IV and V
(C) I, III and V
(D) II, III and IV

2023

71. Niche partitioning among plant-parasitic nematodes on the same plant often occurs by:
(A) Sharing the exact same feeding cell
(B) Spatial separation on different root zones or depths
(C) Mating across species to form hybrids
(D) Producing identical root exudates

2019

72. Which microarthropod group is most commonly known to prey on soil nematodes?
(A) Aphids
(B) Lepidopteran larvae
(C) Collembola and mesostigmatid mites
(D) Herbivorous thrips

2016

73. Which index measures the diversity of a nematode community by considering both the number of species and their relative abundances?
(A) Relative Density Index
(B) Damage Threshold Level
(C) Tolerance Limit
(D) Shannon-Weaver Index

2017

74. Anoxybiosis in nematodes is an adaptive response to:
(A) Lack of oxygen
(B) High oxygen tension
(C) Desiccation
(D) High temperatures

2002

75. Select the correct sequence of the standard nematode life cycle stages:
(A) Egg → J1 → J2 → J3 → J4 → Adult
(B) Egg → J1 → Adult → J2 → J3 → J4
(C) J1 → Egg → J2 → J3 → J4 → Adult
(D) Egg → J2 → J3 → J4 → J1 → Adult

2014

76. In agricultural systems, calculating the Damage Threshold is crucial because it indicates:
(A) The density at which a nematicide acts as a fertilizer
(B) The density where statistically significant yield loss begins
(C) The final population after a crop is harvested
(D) The depth to which nematodes migrate during winter

2022

77. A field shows a high Plant Parasitic Index (PPI) but a low Maturity Index (MI) for free-living species. This suggests:
(A) The field is heavily cultivated, favoring plant parasites
(B) The field is undisturbed native forest
(C) The soil is entirely devoid of organic matter
(D) The field has been fumigated recently

NODIA

2023

78. Which statement is an INCORRECT representation of nematode survival structures?
(A) Cysts are formed from the tanned cuticle of dead females
(B) Gelatinous matrices protect eggs from desiccation
(C) Swollen body types like dauer larvae are highly active and feed aggressively
(D) Eggs can remain dormant for years within cysts

2001

79. Wind-borne dispersal of nematodes is most likely to occur under which conditions?
(A) Heavy clay soils that are highly saturated
(B) In deeply buried subsoil horizons
(C) During heavy monsoon rains
(D) Dry, sandy soils in a state of anhydrobiosis

2022

80. Arrange the following ecological thresholds in typical ascending order of nematode density:
I. Economic Injury Level (EIL)
II. Tolerance Limit (T)
III. Economic Threshold Level (ETL)
(A) II, I, III

2011

101. A low value for Simpson's Index indicates:
(A) High species diversity with no single dominant species
(B) Low species diversity with high dominance
(C) High abundance of predatory nematodes
(D) Complete absence of organic matter

2016

102. Which nematode strategy exemplifies niche partitioning when multiple species occupy the same host?
(A) Both species feeding on the exact same giant cell
(B) Both species hybridizing to share resources
(C) Complete cessation of feeding by both species
(D) Species feeding on different tissue types

2009

103. The primary reason a nematode might undergo diapause is:
(A) To escape sudden, short-term daily temperature spikes
(B) To coordinate its life cycle with the favorable host period
(C) To digest large fungal spores
(D) To increase its rate of locomotion

2023

104. Which of the following is an example of an anthropogenic factor affecting nematode distribution?
(A) Volcanic eruptions
(B) Soil erosion by natural river flow
(C) The international trade of bare-root nursery stock
(D) Continental drift

2016

105. Match the nematode type to its feeding mechanism/behavior:
List I: (Nematode Type)
P. Ectoparasite
Q. Endoparasite
R. Bacterivore
S. Predator
List II: (Feeding Mechanism)
1. Engulfs or pierces small soil invertebrates
2. Feeds on roots while remaining fully in the soil matrix
3. Ingests microbes through a tubular stoma
4. Enters host tissues to feed and complete its life cycle
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-3, R-4, S-2
(D) P-2, Q-1, R-3, S-4

2002

106. In nematode population dynamics, what does the term 'K-strategist' typically imply?
(A) Large body size, long lifespan, and low reproductive rate
(B) High reproductive rate and short lifespan
(C) Extreme sensitivity to anhydrobiosis
(D) Obligate parthenogenesis

2003

107. The presence of a gelatinous matrix around Meloidogyne eggs represents an evolutionary adaptation for:
(A) Enhancing active dispersal
(B) Improving survival against biotic and abiotic stresses
(C) Storing excess carbon
(D) Paralyzing predatory fungi

NODIA

2012

108. Root exudates influence nematode behavior by serving primarily as:
(A) Toxic lethal agents
(B) Infochemicals mediating attraction and hatching
(C) Structural building blocks for the nematode cuticle
(D) Inert physical barriers

2014

109. Which of the following is considered an obligate bacterial parasite of plant-parasitic nematodes?
(A) Pasteuria penetrans
(B) Arthrobotrys oligospora
(C) Purpureocillium lilacinum
(D) Trichoderma harzianum

2008

110. Consider the following statements about soil pH and nematodes:
I. Extreme soil acidity directly kills all nematodes.
II. Soil pH indirectly affects nematodes by altering host plant physiology.
III. Most plant-parasitic nematodes prefer highly alkaline soils (pH > 9).
IV. pH affects the solubility of root exudates.
V. Neutral pH (6.5-7.5) is generally favorable for diverse nematode communities.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II and IV

of individuals
(D) The sample contains only female nematodes

2005

134. Which of the following defines the "Damage Threshold" in crop nematology?
(A) The point at which all plants in the field die
(B) The dosage of nematicide required to kill 50% of the population
(C) The depth of soil where root damage ceases
(D) The density at planting causing minimum detectable yield loss

2002

135. Why are nematodes considered excellent bioindicators of soil health?
(A) They have extremely low abundance in normal soils
(B) They have permeable cuticles, diverse trophic levels, and predictable responses
(C) They are purely chemical entities
(D) They require high levels of heavy metals to survive

2021

136. Which factor most heavily limits the lateral horizontal migration of plant-parasitic nematodes in a field over a single season?
(A) The rotation of the earth
(B) The phase of the moon
(C) Their inherently slow active movement capability
(D) High wind speeds

2013

137. An ecosystem with a high Structure Index (SI) and a low Enrichment Index (EI) is typically:
(A) A highly disturbed agricultural field just after plowing
(B) A heavily polluted urban wasteland
(C) A commercial compost heap
(D) A stable, mature ecosystem with complex food webs

2001

138. The primary difference between the Economic Threshold Level (ETL) and the Economic Injury Level (EIL) is:
(A) The ETL is the population density at which action must be taken to prevent the population from reaching the EIL
(B) The ETL is a theoretical biological maximum, while EIL is purely a farm size measure
(C) The ETL is always higher than the EIL
(D) The ETL applies to predators, the EIL to parasites

2024

139. Which survival mechanism relies on dramatically lowering metabolic rates in response to cold temperatures?
(A) Anhydrobiosis
(B) Cryobiosis
(C) Osmobiosis
(D) Anoxybiosis

2005

140. What is a key disadvantage of relying solely on morphological adaptations (like stylets) to determine a nematode's exact diet?
(A) All nematodes possess identical stylets
(B) Some stylet-bearers may feed on fungi or roots, making assignment difficult
(C) Stylets dissolve during preservation
(D) Morphological features are entirely unlinked to genetics

2021

141. The Colonizer-Persister (c-p) scale ranges from:
(A) 0 to 10
(B) 1 to 5
(C) -1 to +1
(D) 10 to 100

2015

142. A sudden crash in a dense nematode population is mostly likely caused by:
(A) Exponential unlimited resources
(B) An increase in soil oxygen
(C) Crossing carrying capacity leading to resource depletion
(D) A decrease in natural predators

2023

143. Which ecological term describes the role of nematodes that feed on decomposing organic matter and the microbes upon it?
(A) Primary producers
(B) Primary consumers (herbivores)
(C) Apex predators
(D) Detritivores / Microbivores

2011

144. High proportions of plant-parasitic nematodes in an agricultural soil compared to free-living types usually indicate:
(A) A balanced, healthy soil food web
(B) High levels of toxic heavy metals
(C) Monoculture practices and degraded soil health
(D) An abundance of nematophagous fungi

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2006

123. The "niche" of a plant-parasitic nematode includes all the following EXCEPT:
(A) The specific root tissue it feeds on
(B) Geographical latitude defined by political borders
(C) The seasonal timing of its life cycle
(D) Its optimal temperature and moisture requirements

2004

124. Which index best reflects the long-term stability and successional maturity of a soil nematode community?
(A) Enrichment Index
(B) Maturity Index
(C) Simpson's Index
(D) Channel Index

2001

125. Read the following assertion (A) and reason (R) and select the correct option:
Assertion (A): Migratory endoparasitic nematodes like Pratylenchus cause extensive necrotic lesions on host roots.
Reason (R): They continually move through and feed on cortical cells, collapsing cell walls and releasing destructive enzymes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

126. A nematode population showing exponential growth will eventually slow down due to:
(A) An intrinsic genetic clock that limits generations
(B) Spontaneous transition to a free-living state
(C) Density-dependent factors approaching carrying capacity
(D) The elimination of all natural enemies

2008

127. The concept of "age distribution" in a nematode population is important because:
(A) It determines the color of the nematodes
(B) Older nematodes are the primary dispersal agents
(C) It dictates the sex of the offspring
(D) High juvenile proportions indicate high growth potential

2018

128. What role do "hatching factors" play in the ecology of cyst nematodes (Globodera spp.)?
(A) They are chemicals released by the female to kill predators
(B) They are enzymes that digest fungal cell walls
(C) Root exudates that stimulate dormant eggs to hatch
(D) They are internal hormones that cause immediate molting

2023

129. During optimal thermal conditions, the life cycle duration of a plant-parasitic nematode is:
(A) Maximized, taking several years
(B) Minimized, allowing for multiple generations
(C) Unaffected, as nematodes do not depend on temperature
(D) Paused in a state of diapause

2011

130. The mathematical equation for the Simpson's Diversity Index (D) is commonly written as:
(A) $D = -\Sigma(p_i \ln p_i)$
(B) $D = \frac{S}{\ln N}$
(C) $D = N_{\{\max\}} - N_{\{\min\}}$
(D) $D = \Sigma(p_i^2)$

2002

131. Which feature is most characteristic of nematode-parasitic fungi like Catenaria anguillulae?
(A) They produce motile zoospores that seek out and infect nematodes
(B) They form massive fruiting bodies above ground
(C) They rely entirely on wind dispersal
(D) They are strictly autotrophic

2002

132. The process of modifying host root cells into multinucleate "giant cells" is an ecological strategy employed by:
(A) Pratylenchus spp.
(B) Ditylenchus spp.
(C) Meloidogyne spp.
(D) Aphelenchoides spp.

2008

133. When measuring relative abundance, "evenness" ensures that:
(A) No single species completely dominates the community numerically
(B) The physical sizes of all nematodes are equal
(C) Every species has exactly the same number

NODIA

(A) Complex polycyclic aromatic hydrocarbons
(B) Amino acids, sugars, and organic acids
(C) Inorganic silica and mica dust
(D) Elemental pure sulfur

2010

156. An exception to the general rule that plant-parasitic nematodes are microscopic is the genus:
(A) Meloidogyne
(B) Paralongidorus
(C) Pratylenchus
(D) Globodera

2016

157. Which environmental condition is most likely to trigger the formation of dauer larvae in Caenorhabditis elegans?
(A) High population density, food scarcity, and elevated temperature
(B) Abundant food and low population density
(C) Neutral pH and high oxygen
(D) Continuous optimal moisture levels

2001

158. Nematodes are classified as poikilothermic, meaning:
(A) They generate their own internal body heat
(B) They require extreme heat to survive
(C) Their body temperature fluctuates with the surroundings
(D) They possess complex sweat glands

2005

159. The relative yield (y) in the Seinhorst equation is expressed as:
(A) A value between 0 and 1 (or 0% to 100%)
(B) An absolute tonnage per hectare
(C) A negative integer
(D) A ratio of nematodes to bacteria

2001

160. Which characteristic makes the Plant Parasitic Index (PPI) a useful agricultural metric?
(A) It perfectly predicts global weather patterns
(B) It measures the exact amount of chemical nematicide remaining
(C) It correlates with crop health and parasite burden
(D) It only counts beneficial predatory nematodes

2005

161. A field capacity moisture level is ecologically optimal for nematodes primarily because:
(A) It floods the pores, removing all oxygen
(B) It ensures moisture films while allowing oxygen diffusion
(C) It maximizes soil compaction
(D) It reduces soil temperature to freezing

2014

162. How do organic amendments generally influence nematode communities?
(A) They uniformly kill all nematodes present
(B) They suppress bacterivores and promote plant-parasites
(C) They immediately convert all soils to a climax ecosystem
(D) They stimulate microbivorous nematodes, increasing the EI

2003

163. The primary reason why sandy soils often exhibit higher damage from Meloidogyne species compared to clay soils is:
(A) Sandy soils provide larger pores and aeration for movement
(B) Sandy soils contain more native predators
(C) Meloidogyne cannot synthesize its stylet in clay
(D) Sandy soils are inherently colder

2001

164. Which statistical metric measures the degree of dispersion or aggregation of a nematode population in a field?
(A) Tolerance limit
(B) Shannon's H'
(C) Variance-to-mean ratio
(D) Logistic growth constant

2012

165. Read the following assertion (A) and reason (R) and select the correct option:
Assertion (A): Anthropogenic movement of soil and plant material is a major factor in the spread of quarantine nematodes.
Reason (R): Nematodes lack the physical adaptations for rapid, long-distance autonomous terrestrial migration.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

166. A nematode community with extremely low evenness is dominated by:
(A) A wide variety of species in equal numbers
(B) Only predatory nematodes
(C) Fungal hyphae

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2002

145. Match the ecological index with its specific interpretive value:
List I: (Ecological Index)
P. Maturity Index
Q. Enrichment Index
R. Channel Index
S. Structure Index
List II: (Interpretive Value)
1. Indicates fungal vs. bacterial decomposition
2. Reflects overall soil disturbance and successional state
3. Reflects the food web complexity and presence of omnivores/predators
4. Indicates availability of readily decomposable organic resources
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-1, R-4, S-2

2014

146. A major adaptation of cyst nematodes (Heterodera spp.) for long-term survival is:
(A) The continuous swimming of juveniles in groundwater
(B) The complete shedding of the cuticle every two days
(C) The utilization of atmospheric carbon dioxide for energy
(D) The hardening of the body wall to form a protective cyst

2012

147. Which mathematical model best describes a nematode population growth in a limited environment over a long period?
(A) Logistic growth model
(B) Linear regression
(C) Exponential growth model
(D) Inverse-square law

2006

148. Predatory nematodes are generally classified on the c-p scale as:
(A) c-p 1 or 2
(B) c-p 4 or 5
(C) c-p 0
(D) c-p 10

2022

149. The Shannon-Weaver Diversity Index (H') accounts for both:
(A) Species richness and species evenness
(B) Soil pH and moisture
(C) Carrying capacity and growth rate
(D) Nematode length and weight

2013

150. Which ecological phenomenon describes the situation where Meloidogyne incognita prevents root colonization by Rotylenchulus reniformis due to prior establishment?
(A) Mutualism
(B) Sympatric speciation
(C) Commensalism
(D) Antagonistic competitive exclusion

2016

151. Which factor acts as a critical signal for the termination of nematode diapause in many temperate species?
(A) A sudden increase in soil salinity
(B) A period of chilling followed by warming
(C) Total depletion of soil moisture
(D) Complete darkness for six months

2010

152. In a nematode life table, the calculation of net reproductive rate (R_0) requires integrating data on:
(A) Maximum movement speed and stylet length
(B) Soil pore size and water potential
(C) Age-specific survival (l_x) and fecundity (m_x)
(D) Carbon-to-nitrogen ratio of the soil

2015

153. What is the most relevant consequence of agricultural deep plowing on nematode ecology?
(A) It permanently eradicates all nematode species
(B) It changes the genetic makeup of the nematodes
(C) It causes an instant transition from parasitism to autotrophy
(D) It disrupts spatial distribution and kills sensitive persisters

2014

154. The initial nematode density (P_i) is a critical parameter in predictive nematology because:
(A) It is the primary independent variable determining yield loss
(B) It dictates the color of the host plant's flowers
(C) It is always a constant value across all fields
(D) It determines the market price of the crop

NODIA

2022

155. Which group of root exudate compounds has been heavily implicated in attracting plant-parasitic nematodes?

(C) III and V
(D) I and V

2017

111. Which mathematical index places heavy weight on the dominance of the most common species in a nematode community?
(A) Species Richness
(B) Shannon-Weaver Index
(C) Maturity Index
(D) Simpson's Index

2009

112. The structure of the soil food web heavily relies on nematodes because they:
(A) Are the primary autotrophs in dark soils
(B) Fix atmospheric nitrogen directly
(C) Occupy almost every trophic level in the micro-fauna
(D) Decompose complex lignin faster than fungi

2023

113. During anhydrobiosis, a nematode physically alters its shape to:
(A) An elongated, rigid straight line to pierce soil clumps
(B) A tightly coiled shape to reduce water loss
(C) A flattened disc to absorb dew
(D) A swollen sphere to float on air currents

2015

114. Which nematode genus is known for transmitting plant viruses during its feeding process?
(A) Meloidogyne
(B) Heterodera
(C) Pratylenchus
(D) Xiphinema

2016

115. What primary mechanism limits the maximum depth of vertical nematode distribution in most soils?
(A) Lack of host roots and reduced oxygen levels
(B) Extreme high temperatures in the subsoil
(C) Increased light penetration
(D) Elevated atmospheric pressure

2023

116. Which of the following correctly pairs a nematode genus with its ecological feeding category?
(A) Heterodera - Migratory ectoparasite
(B) Pratylenchus - Sedentary endoparasite
(C) Tylenchulus - Semi-endoparasite
(D) Mononchus - Fungivore

2012

117. An increase in the Enrichment Index (EI) immediately following tillage and fertilization is primarily driven by:
(A) A rapid multiplication of c-p 1 bacterivorous nematodes
(B) A surge in large predaceous nematodes
(C) A decline in all biological activity
(D) An influx of cyst nematodes

2017

118. Which biological factor most often acts as an antagonist suppressing nematode populations in suppressive soils?
(A) High organic matter
(B) The presence of susceptible host plants
(C) Abundant soil moisture
(D) Nematophagous fungi and parasitic bacteria

2016

119. A life table typically does NOT include data on:
(A) Survivorship to specific ages
(B) The atomic mass of soil minerals
(C) Fecundity at specific ages
(D) Age-specific life expectancy

2017

120. Which feature distinguishes a fungivorous nematode from a bacterivorous one?
(A) A wide, unarmed stoma
(B) Complete lack of an esophagus
(C) Presence of a delicate stylet for hyphal piercing
(D) An obligate requirement for root exudates

2024

121. The term "synergism" in nematode-fungal disease complexes refers to:
(A) Nematodes feeding on the fungus to survive
(B) The fungus trapping and killing the nematode
(C) The plant developing complete resistance to both
(D) Combined damage greater than the sum of individual damage

2017

122. Soil moisture influences nematode movement by:
(A) Regulating the thickness of water films for optimal leverage
(B) Dissolving the nematode's cuticle in saturated conditions
(C) Triggering anhydrobiosis whenever water is present
(D) Generating high-voltage electrical fields

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(D) One or a few highly abundant species

2006

167. The "syncytium" induced by cyst nematodes differs from the "giant cells" of root-knot nematodes primarily in its formation by:
(A) Repeated mitosis without cytokinesis
(B) Cell wall dissolution and protoplast fusion of adjacent cells
(C) Massive accumulation of starch granules
(D) Total immediate cell death

2011

168. Which trophic group is most directly involved in releasing nitrogen locked in bacterial biomass, making it available to plants?
(A) Plant-parasitic nematodes
(B) Fungivorous nematodes
(C) Bacterivorous nematodes
(D) Omnivorous nematodes

2023

169. What does the term "ovoviviparous" mean when applied to certain nematodes?
(A) Females lay unfertilized eggs that never hatch
(B) Males carry the eggs until hatching
(C) Eggs are laid in a thick gelatinous matrix outside the body
(D) Eggs hatch inside the body, and live juveniles emerge

2015

170. Which mechanism best describes how obligate endoparasites overcome the host plant's internal osmotic pressure?
(A) They possess an impermeable cuticle and excretory systems
(B) They drink large volumes of xylem fluid
(C) They actively transport salt out of the plant cell
(D) They do not face any osmotic pressure inside the root

2008

171. A major ecological consequence of anoxybiosis is:
(A) Accelerated growth and reproduction
(B) Suspension of aerobic respiration and movement
(C) Immediate death within minutes
(D) Transformation into a fungivorous form

2012

172. When analyzing a nematode life table, a Type I survivorship curve indicates:
(A) High mortality in early life stages
(B) Low mortality until late in life
(C) Constant mortality across all age groups
(D) No mortality whatsoever

2010

173. The mathematical constant 'e' in the Seinhorst model base equation ($z = e^{\{-c\}}$) represents:
(A) The base of the natural logarithm
(B) Environmental resistance
(C) Economic threshold
(D) Energy flow

2003

174. Which process most strongly influences the horizontal patchy distribution of nematodes in an unplowed field?
(A) Uniform wind distribution
(B) Sunspot activity
(C) Localized host root growth and limited active movement
(D) The coriolis effect

2005

175. Why are c-p 1 nematodes referred to as "enrichment opportunists"?
(A) They only survive in nutrient-poor environments
(B) They enrich the soil with toxic heavy metals
(C) They prey on larger persister nematodes
(D) They respond explosively to pulses of organic matter

2006

176. Which of the following is a classic biological control agent acting as an obligate parasite of female root-knot nematodes and eggs?
(A) Trichoderma viride
(B) Bacillus thuringiensis
(C) Pasteuria penetrans
(D) Pseudomonas fluorescens

NODIA

2024

177. In the context of nematode feeding, what does the "esophageal bulb" do?
(A) It stores lipid reserves for overwintering
(B) It functions as a muscular pump to ingest food and secrete enzymes
(C) It acts as the primary visual organ
(D) It produces the protective cyst wall

2025

178. The Tolerance Limit (T) is highly dependent on:
(A) Only the nematode species present
(B) Only the soil type
(C) The lunar cycle
(D) A combination of host, environment, and

(D) Verhulst-Pearl model

2003

201. Why are root-lesion nematodes (Pratylenchus spp.) classified as migratory endoparasites?
(A) They remain outside the root and move along the surface
(B) They enter the root, become immobile, and form galls
(C) They migrate out of the soil to feed on leaves
(D) They move through cortical tissues while laying eggs

2014

202. Which morphological feature is most critical for a nematode's ability to survive anhydrobiosis?
(A) A flexible cuticle allowing coiling and moisture retention
(B) A highly active, large stylet
(C) Massive development of esophageal glands
(D) Long sensory setae

2002

203. The primary reason for assessing the Tolerance Limit (T) before applying nematicides is that:
(A) Nematicides are entirely ineffective below this limit
(B) Below T, the crop suffers no economic damage
(C) Below T, nematodes mutate to become resistant
(D) Above T, the crop becomes toxic to humans

2016

204. Which of the following is a density-dependent factor affecting nematode population growth?
(A) Severe drought
(B) Exhaustion of host root resources
(C) Flooding
(D) Tillage

2013

205. In the formula for logistic growth, $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$. What happens when the population size (N) approaches the carrying capacity (K)?
(A) The population growth rate approaches zero
(B) The population growth rate becomes exponential
(C) The carrying capacity doubles
(D) The intrinsic rate of increase (r) becomes zero

2005

206. Which ecological metric provides a snapshot of the nutritional status of the soil food web?
(A) Maturity Index
(B) Simpson's Diversity
(C) Enrichment Index
(D) Species Richness

2012

207. A characteristic symptom of attack by ectoparasitic nematodes like Belonolaimus is:
(A) Large, distinctive root galls
(B) Swollen, white cysts on the roots
(C) Extensive stem rotting
(D) Stunted, stubby root systems with no fine root development

2018

208. The main difference between Simpson's Index and the Shannon-Weaver Index is that Simpson's Index is:
(A) More sensitive to changes in rare species
(B) Based entirely on total nematode mass
(C) More sensitive to changes in the dominant species
(D) Unaffected by species richness

2017

209. Nematode movement relies heavily on the physical principle of:
(A) Aerodynamic lift
(B) Hydrostatic pressure against a cuticle acting on soil surface tension
(C) Jet propulsion
(D) Magnetic levitation

2021

210. Which group of nematodes is most sensitive to agricultural tillage, thus serving as an indicator of physical soil disturbance?
(A) Opportunistic bacterivores
(B) Root-knot nematodes
(C) Cyst nematodes
(D) Large dorylaimid persisters

2005

211. The phenomenon of "hatching factor" dependence in Globodera rostochiensis serves to:
(A) Ensure juveniles emerge in the presence of growing host roots
(B) Maximize exposure to winter cold
(C) Delay hatching indefinitely
(D) Repel natural predators

2007

212. What primary effect does a sudden drop in soil temperature below the thermal minimum have on active root-knot nematode juveniles?
(A) It induces immediate cell division

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2012

189. A soil food web diagnostic showing a high Channel Index (CI) indicates:
(A) Decomposition is dominated by fungal pathways
(B) Decomposition is dominated by bacterial pathways
(C) There is no decomposition occurring
(D) The soil is perfectly sterile

2008

190. Which of the following is NOT an advantage of parthenogenesis for plant-parasitic nematodes?
(A) Rapid population expansion
(B) Elimination of time and energy to find a mate
(C) High genetic variation for adaptation to resistance
(D) Ability of a single individual to initiate a new infestation

2011

191. Nematode population dynamics are fundamentally driven by the balance between:
(A) Chemical applications and lunar cycles
(B) Soil sand and silt content
(C) Photosynthesis and respiration
(D) Natality, mortality, immigration, and emigration

2017

192. Which spatial distribution pattern is mathematically described when the variance is significantly greater than the mean?
(A) Regular
(B) Uniform
(C) Aggregated (Clumped)
(D) Random

2021

193. The primary evolutionary driver for the development of sedentary endoparasitism in nematodes is thought to be:
(A) Maximizing exposure to soil predators
(B) Securing a protected food sink while minimizing movement energy
(C) Improving aerobic respiration rates
(D) Facilitating continuous molting

2001

194. In calculating the Shannon-Weaver Index, p_i represents:
(A) The physical mass of species i
(B) The precise length of species i
(C) The reproductive rate of species i
(D) The proportion of individuals belonging to species i

2021

195. Which interaction is a clear example of a concomitant infection exacerbating plant disease?
(A) Meloidogyne incognita facilitating Fusarium oxysporum infection
(B) Pasteuria penetrans infecting Meloidogyne incognita
(C) Mononchus killing Pratylenchus
(D) Marigold roots releasing thiophenes

2016

196. An increase in species richness within a nematode community, holding all else constant, will:
(A) Decrease the Shannon-Weaver Index
(B) Result in a negative Simpson's Index
(C) Increase the Shannon-Weaver Index
(D) Have mathematically zero effect on any index

2013

197. Which type of nematode is typically found in the highest abundance in the undisturbed O horizon of a forest soil?
(A) Omnivores and diverse free-living fungivores/ bacterivores
(B) Sedentary plant parasites
(C) Strictly aquatic marine nematodes
(D) Obligate entomopathogens only

2013

198. Overwintering eggs of Meloidogyne are primarily protected from freezing and desiccation by:
(A) The thick cyst wall
(B) A heavily tanned cuticle
(C) The egg itself through deep burrowing behavior
(D) The gelatinous matrix secreted by the rectal glands

2013

199. What does the term "ETL" stand for in pest management?
(A) Environmental Toxicity Level
(B) Economic Threshold Level
(C) Ecological Tolerance Limit
(D) Estimated Treatment Loss

2023

200. The concept of "carrying capacity" is absent from which population growth model?
(A) Logistic model
(B) Density-dependent model
(C) Exponential model

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species

2014

179. A highly diverse soil nematode community (high Shannon-Weaver index) generally implies:
(A) A resilient ecosystem with multiple active trophic levels
(B) Severe chemical contamination
(C) A monoculture cropping system
(D) Total absence of organic matter

2002

180. Which factor is most critical in defining the difference between the ETL and EIL?
(A) The exact number of nematode eggs
(B) The soil pH
(C) Control costs versus the financial value of saved yield
(D) The duration of anhydrobiosis

2011

181. What physical property of a soil indicates low total pore space, thereby restricting nematode habitation?
(A) High bulk density
(B) High organic matter content
(C) High sand content
(D) High moisture level

2010

182. Which of the following best explains why some nematode species form galls?
(A) Galls act as a physical trap for predatory mites
(B) Galls are formed purely to kill the host plant rapidly
(C) Galls facilitate wind dispersal of the roots
(D) Galls provide a localized, nutrient-rich cellular sink

2014

183. Intraspecific competition in a dense population of root-knot nematodes often leads to:
(A) Increased body size of females
(B) Development of more males as a stress response
(C) Enhanced egg production per female
(D) Immediate conversion to a predatory lifestyle

2013

184. The intrinsic rate of increase (r_m) is mathematically defined under which conditions?
(A) When resources are severely limited
(B) When the population is facing high predation
(C) Ideal, uncrowded conditions with unlimited resources
(D) When the temperature is below freezing

2005

185. Match the following parameters with their definitions:
List I: (Parameters)
P. Carrying capacity (K)
Q. Tolerance Limit (T)
R. Economic Injury Level (EIL)
S. Minimum yield (m)
List II: (Definitions)
1. Lowest relative crop yield at maximum nematode density
2. Nematode density where cost of control equals value of yield saved
3. Maximum population size sustainable by the environment
4. Density threshold below which no yield loss is observed
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-3, S-1

2003

186. Which nematode life stage is most vulnerable to soil fumigants?
(A) Active, migrating second-stage juveniles (J2) in soil pores
(B) Eggs encased inside an intact cyst
(C) Anhydrobiotic dauer larvae
(D) Deeply embedded adult females

2006

187. "Nematicidal" plants like Marigold (Tagetes spp.) suppress nematodes primarily through:
(A) Physically crushing nematodes with rapidly expanding roots
(B) Releasing toxic allelochemicals into the rhizosphere
(C) Increasing soil temperature to lethal levels
(D) Depleting soil oxygen completely

NODIA

2022

188. Which characteristic of the cuticle allows nematodes to survive in fluctuating osmotic environments?
(A) It is composed of rigid, impermeable chitin like insect exoskeletons
(B) It is a selectively permeable, multi-layered collagenous matrix
(C) It continuously secretes toxic heavy metals
(D) It dissolves when exposed to water

(B) It forces them to molt rapidly
(C) It paralyzes them, halting locomotion and root penetration
(D) It causes them to form cysts

2023

213. "Species Evenness" reaches its maximum theoretical value when:
(A) All species in the sample have the exact same number of individuals
(B) Only one species exists in the sample
(C) The largest species dominates the biomass
(D) The population is zero

2015

214. Which factor most limits the usefulness of biological control agents like predatory nematodes in broad-scale agriculture?
(A) They are too cheap to produce
(B) They grow too fast and consume the crop
(C) They cannot survive in any soil type
(D) They require specific soil environments easily disrupted by farming

2007

215. The interaction where two competing plant-parasitic nematode species eventually settle into separate niches on the same root system is termed:
(A) Competitive exclusion
(B) Resource partitioning
(C) Obligate mutualism
(D) Genetic hybridization

2018

216. A high proportion of fungivorous nematodes in a soil sample often correlates with:
(A) Intensive application of inorganic nitrogen fertilizer
(B) A completely flooded, anaerobic paddy field
(C) Soil systems rich in complex, slowly decomposing organic matter
(D) Bare, sterile sand

2018

217. Nematodes with a short life cycle, high reproductive rate, and high tolerance to environmental stress are typical:
(A) K-strategists
(B) Apex predators
(C) Climax community indicators
(D) r-strategists

2014

218. The principle of the Baermann funnel technique for nematode extraction relies primarily on:
(A) The density difference between nematodes and soil
(B) The active movement of nematodes through a filter
(C) The chemical attraction of nematodes to water
(D) The size of the nematode eggs

2023

219. Which best describes the ecological function of an omnivorous dorylaimid?
(A) It exclusively eats fungal spores
(B) It acts as a keystone species connecting multiple trophic levels
(C) It operates solely as a primary producer
(D) It only parasitizes mammalian hosts

2024

220. The "Structure Index" (SI) is calculated using the relative abundance of:
(A) Bacterivores and fungivores only
(B) Omnivores and predatory nematodes (c-p 3 to 5)
(C) Only c-p 1 nematodes
(D) Plant-parasitic nematodes exclusively

2003

221. Which survival mechanism is most closely associated with the genus Anguina?
(A) Anhydrobiosis of juveniles within seed galls
(B) Formation of protective cysts in the soil
(C) Ovoviviparity in damp soil
(D) Symbiosis with earthworms

2022

222. The term "nematode faunal analysis" primarily refers to:
(A) The chemical breakdown of nematode cuticles
(B) Counting only the male nematodes in a sample
(C) Evaluating soil health by assessing entire nematode communities
(D) Measuring the physical length of root-knot galls

2023

223. What role does carbon dioxide play in nematode ecology within the soil?
(A) High levels cause rapid reproduction
(B) It acts as a primary energy source via photosynthesis
(C) It dissolves the stylet
(D) It serves as a gradient cue for locating respiring host roots

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(C) They lose their stylet entirely
(D) They elongate to over 10 cm in length

2021

294. The calculation of species richness (S) is defined simply as:
(A) The physical weight of the sample
(B) The ratio of predators to prey
(C) The sum of all individuals across all species
(D) The total count of unique species identified in a sample

2010

295. Which of the following is a vital function of the gelatinous matrix produced by root-knot nematodes?
(A) It acts as an attractant for males
(B) An antimicrobial barrier protecting eggs from desiccation
(C) It contains powerful enzymes that digest the host root
(D) It propels the female through the soil

2024

296. When plotting the Seinhorst model, the x-axis typically represents:
(A) Relative crop yield
(B) Time in months
(C) Initial nematode density (P_i) on a logarithmic scale
(D) Soil pH

2015

297. In a highly disturbed agricultural soil, the nematode community is most likely to be dominated by:
(A) c-p 4 and 5 nematodes
(B) c-p 1 and 2 nematodes
(C) Only predatory nematodes
(D) Obligate marine nematodes

NODIA

2018

298. Which adaptive strategy best explains the high invasive success of root-knot nematodes across diverse global systems?
(A) Parthenogenesis, polyphagy, and efficient anhydrobiotic survival
(B) They reproduce exclusively via amphimixis
(C) They have an incredibly narrow host range
(D) Their large size, which deters all predators

2006

299. The "Tolerance Limit" (T) conceptually marks the threshold where:
(A) The crop stops growing entirely
(B) Compensatory growth cannot overcome damage by increasing populations
(C) The nematode population begins to decline
(D) The soil becomes too toxic for any life

2023

300. The Enrichment Index (EI) is primarily driven upward by an increase in the abundance of:
(A) Slow-growing predatory nematodes
(B) Fast-growing bacterivores responding to nutrient pulses
(C) Plant-parasitic nematodes inside roots
(D) Cyst nematodes waiting for a host

****

2001

236. The biological phenomenon of "diapause" in nematodes is best distinguished from simple quiescence by:
(A) Being induced solely by an immediate lack of food
(B) Being a genetically programmed arrest requiring specific cues
(C) Lasting only a few hours
(D) Occurring exclusively in adult males

2024

237. The calculation of a nematode community's "Maturity Index" involves:
(A) Summing the proportion of each taxon multiplied by its c-p value
(B) Multiplying the total count by soil pH
(C) Dividing the number of predators by the number of bacterivores
(D) Subtracting the number of plant parasites from total abundance

2024

238. Which type of nematodes are generally the first to colonize a completely sterilized soil once organic matter is added?
(A) Dorylaimid persisters (c-p 5)
(B) Sedentary plant-parasites (c-p 3)
(C) Opportunistic bacterivores (c-p 1), such as Rhabditidae
(D) Mononchid predators (c-p 4)

2012

239. The most significant abiotic pathway for the inter-continental spread of cyst nematodes has historically been:
(A) High-altitude wind currents blowing cysts across oceans
(B) Migratory whales
(C) Deep ocean currents
(D) Global trade of contaminated seed and agricultural machinery

2001

240. Which environmental factor serves as the primary barrier preventing widespread deep soil nematode populations?
(A) Extreme high temperatures
(B) Increased soil porosity
(C) Lack of oxygen and host plant roots
(D) Toxicity of bedrock minerals

2023

241. What is the evolutionary advantage of the "giant cell" complex formed by Meloidogyne?
(A) It shields the nematode from extreme temperatures
(B) It acts as a metabolic sink funneling nutrients to the nematode
(C) It produces toxins that kill all competing fungi
(D) It allows the nematode to photosynthesize

2006

242. In a life table, the age-specific fecundity column (m_x) records:
(A) The number of predators at age x
(B) The probability of death before age x
(C) The size of the nematode at age x
(D) Average number of female offspring produced per female at age x

2001

243. "Concomitant infection" between root-knot nematodes and wilt fungi generally results in:
(A) Earlier and more severe wilt symptoms than if fungus was alone
(B) A decrease in wilt incidence
(C) The complete disappearance of both pathogens
(D) The production of a new fungal species

2014

244. The feeding behavior of a semi-endoparasitic nematode like Rotylenchulus reniformis dictates that its eggs are usually deposited:
(A) Deep inside the vascular cylinder
(B) On the leaves of the host plant
(C) Outside the root in a gelatinous matrix within the soil
(D) Inside the nematode's own shed cuticle

2024

245. Which of the following is a primary characteristic of a K-selected nematode species?
(A) Long life span and slow population growth
(B) Large brood sizes
(C) Rapid completion of the life cycle
(D) High tolerance for acute chemical toxicity

2003

246. What fundamental shift occurs in a soil food web moving from an Enrichment Index (EI) > 80 to a basal, unstressed state?
(A) Fungal pathways and higher trophic levels begin to dominate
(B) Bacterivores entirely consume the persisters
(C) Plant-parasites become the only surviving organisms
(D) Total biomass increases infinitely

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susceptible host plant. By bypassing the need to locate mates, parthenogenetic species maximize their reproductive potential and efficiently exploit favorable agricultural environments.

10. (A) I and II
Sandy soils possess large, well-aerated pore spaces that physically accommodate the movement of larger nematode species. In contrast, heavy clay soils contain tiny, compacted pores that mechanically restrict locomotion. Soil structure, pore size distribution, and moisture availability directly dictate nematode habitability, meaning that soil physical characteristics are critical determinants of their distribution and migration.

11. (B) Field capacity
Soil moisture at field capacity provides the absolute optimum environment for nematode activity, movement, and respiration. At this state, the larger soil pores are filled with air while the smaller pores retain water films. This balance ensures sufficient oxygen diffusion for aerobic respiration while providing ideal water film thickness for efficient sinusoidal locomotion.

12. (B) They induce a state of dormancy or diapause
Temperature extremes outside a nematode's optimal physiological range generally disrupt normal embryogenesis and development. To survive these unfavorable conditions, nematodes often enter a state of dormancy or diapause, temporarily halting their development. This adaptation protects the sensitive developing embryo inside the egg shell from lethal freezing or heat stress until favorable temperatures return.

13. (A) Reduced survival and activity of plant-parasitic nematodes
Saturated and waterlogged soils suffer from highly restricted gas exchange, leading to rapid oxygen depletion and elevated carbon dioxide concentrations. Most plant-parasitic nematodes are obligate aerobes that require oxygen to sustain their metabolism. Anaerobic conditions severely impair their respiration, paralyzing active juveniles, reducing overall survival rates, and halting host-seeking behavior in the soil.

14. (C) Specific host-derived allelochemical compounds
Many cyst nematodes have evolved highly specialized relationships with their host plants, relying on chemical cues to hatch. Root exudates contain specific host-derived allelochemical compounds that act as hatching factors. These chemical signals bind to sensory receptors on the nematode egg, stimulating the dormant juvenile to produce enzymes, breach the egg shell, and emerge.

15. (A) Both A and R are true and R is the correct explanation of A.
Nematophagous fungi are specialized soil organisms that actively hunt and digest nematodes to obtain nitrogen. In the presence of nematodes, these fungi develop intricate trapping structures such as constricting rings, adhesive nets, or knobs. Once a nematode is trapped, the fungal hyphae penetrate the cuticle, digest the internal contents, and absorb the nutrients.

16. (C) Niche partitioning or competitive exclusion
When multiple plant-parasitic nematode species infect the same host plant, they compete intensely for limited root space and nutrients. This interspecific competition typically drives niche partitioning, where species adapt to feed on different root zones or tissue depths. If their niches overlap completely, competitive exclusion occurs, resulting in one dominant species suppressing the other.

NODIA

17. (B) Age-specific mortality and natality rates
A nematode life table is a fundamental demographic tool used to track and analyze population dynamics over time. It relies on compiling age-specific survival, mortality, and natality rates within a cohort. These biological parameters allow ecologists to calculate reproductive potential, average life expectancy, and the intrinsic rate of population increase under specific environmental conditions.

18. (D) Protect viable eggs during unfavorable environments
Cysts formed by species like Globodera are durable survival structures made from the tanned, hardened cuticle of the dead female. This chemical transformation creates a highly resilient barrier that encases and protects hundreds of viable eggs. The cyst shields the eggs from desiccation, freezing temperatures, microbial attack, and chemical nematicides for many years.

(A) Species richness increases dramatically
(B) Total abundance drops, followed by a bloom of c-p 1 opportunists
(C) Persister nematodes dominate instantly
(D) The Maturity Index rises to 5

2019

260. What is the primary effect of long-term flooding on the survival of most terrestrial plant-parasitic nematodes?
(A) It provides optimal moisture for reproduction
(B) It promotes the growth of host roots
(C) It leads to anaerobic conditions that are lethal over time
(D) It increases the salinity of the soil

2024

261. Nematode "life tables" are primarily used in ecology to:
(A) Determine age-specific survival, fecundity, and predict growth
(B) Calculate the exact chemical composition of the cuticle
(C) Classify nematodes taxonomically
(D) Measure the exact amount of carbon in a single nematode

2025

262. Which of the following best characterizes the reproductive strategy of Meloidogyne incognita under favorable environmental conditions?
(A) Obligate amphimixis requiring a 1:1 male to female ratio
(B) Hermaphroditism with occasional outcrossing
(C) Ovoviviparity with no egg stage
(D) Mitotic parthenogenesis allowing rapid multiplication

2004

263. The Channel Index (CI) is a highly useful ecological metric because it indicates:
(A) The physical depth of plow channels
(B) Whether decomposition is driven by bacteria or fungi
(C) The speed of water flow through soil water macropores
(D) The rate of wind erosion

2019

264. What is the consequence of continuous monoculture of a susceptible crop on nematode population dynamics?
(A) It leads to the rapid eradication of the target nematode
(B) It increases the complexity and evenness of the entire food web
(C) It causes an exponential rise in specific nematode populations
(D) It naturally induces complete anhydrobiosis

2008

265. The minimum yield (m) in the Seinhorst equation reflects:
(A) The yield at zero nematode density
(B) The yield lost entirely to fungi
(C) The yield exactly at the tolerance limit
(D) Residual yield at the maximum possible nematode density

2008

266. A defining feature of predatory nematodes in the order Mononchida is:
(A) A heavily sclerotized, barrel-shaped stoma with large teeth
(B) A delicate, hollow stylet
(C) The absence of any mouthparts
(D) A swollen, sedentary female body

2001

267. Nematodes regulate bacterial populations not only by consumption but also by:
(A) Secreting powerful antibiotics that kill all bacteria
(B) Dispersing bacterial cells to new soil microhabitats
(C) Converting them directly into plant roots
(D) Creating an entirely sterile environment

2013

268. Which physical factor primarily dictates the upper lethal temperature limit for a given nematode species?
(A) The melting point of soil silica
(B) The temperature where critical proteins and enzymes denature
(C) The boiling point of water
(D) The rate of evaporation at the soil surface

2018

269. A community with a Shannon-Weaver Index (H') close to zero indicates:
(A) A highly disturbed community dominated by a single species
(B) High diversity and high evenness
(C) The complete absence of life
(D) A stable climax ecosystem

2012

270. Which of the following is considered an antagonist that actively traps and consumes nematodes?
(A) Pasteuria penetrans

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2002

224. Which term describes the number of individuals of a single species per unit of soil volume or weight?
(A) Diversity
(B) Biomass
(C) Density
(D) Richness

2016

225. A soil sample reveals high species richness, high evenness, a high Maturity Index, and low Plant Parasitic Index. This environment is likely:
(A) A heavily degraded mono-cropped field
(B) An undisturbed natural ecosystem
(C) A recently fumigated greenhouse bench
(D) An industrial mine tailing site

2006

226. Which anatomical adaptation allows a nematode to maintain high internal body pressure without bursting?
(A) A rigid skeleton made of calcium carbonate
(B) A porous epidermis
(C) The lack of any internal fluids
(D) A strong, multilayered cuticle acting against hydrostatic pressure

2024

227. The most critical factor determining whether an anhydrobiotic nematode can successfully revive upon rehydration is:
(A) A slow, controlled rate of rehydration to prevent membrane rupture
(B) The speed at which it coiled
(C) The presence of a host root nearby
(D) The absolute size of the nematode

2010

228. Nematode survival in completely saturated, flooded soil is generally poor due to:
(A) High oxygen tension
(B) Increased light penetration
(C) Depletion of oxygen and accumulation of toxic byproducts
(D) Spontaneous dissolving of the cuticle

2009

229. Which group of plant-parasitic nematodes is most likely to transmit nepoviruses?
(A) Longidoridae and Xiphinematidae
(B) Meloidogynidae
(C) Heteroderidae
(D) Pratylenchidae

2024

230. The mathematical relationship between nematode density and crop yield in the Seinhorst model is best described as:
(A) A straight linear decline
(B) A sigmoidal curve
(C) A perfect bell curve
(D) An exponential decline curve up to a minimum yield (m)

2013

231. The primary cause of localized "hot spots" of nematode infestation in agricultural fields is:
(A) The random fall of rain
(B) Clustered inoculum, limited movement, and repeated cultivation
(C) Uniform distribution of soil organic matter
(D) Global wind patterns

2023

232. What dictates the "field capacity" of a soil?
(A) The point where all pore spaces are filled with water
(B) The point where plants permanently wilt
(C) The maximum amount of water a soil holds against gravity
(D) The total volume of sand in the soil

2022

233. In the formula for the Economic Injury Level ($EIL = \frac{C}{V \times D \times K}$), the variable '$C$' represents:
(A) Crop value
(B) Damage per nematode
(C) Carrying capacity
(D) Cost of control measures per unit area

2022

234. Which of the following is considered an indirect effect of soil temperature on nematodes?
(A) Alteration of host root growth and food availability
(B) Freezing of internal body fluids
(C) Denaturation of nematode enzymes
(D) Immediate mortality from heat shock

2014

235. A major limitation of utilizing the Species Richness index alone is that it:
(A) Overemphasizes the dominant species
(B) Ignores relative abundance of each species
(C) Requires knowing the exact genetic sequence
(D) Only counts predatory nematodes

NODIA

(A) Logistic growth model
(B) Exponential growth model
(C) Linear decay model
(D) Inverse square model

2007

283. Which statement accurately describes the feeding behavior of an endoparasite compared to an ectoparasite?
(A) Endoparasites remain outside the root; ectoparasites enter the root
(B) Endoparasites fully enter host tissue; ectoparasites feed from outside
(C) Endoparasites do not have a stylet
(D) Both feed exclusively on the leaves

2017

284. A major ecological factor contributing to the natural suppression of nematodes in "suppressive soils" is:
(A) The complete absence of water
(B) High populations of antagonistic fungi and bacteria
(C) Extremely high soil temperatures
(D) The presence of toxic heavy metals

2005

285. In nematode ecology, the term "niche partitioning" is best demonstrated when:
(A) Species establish feeding sites in separate root tissue zones
(B) Two nematode species hybridize
(C) Two competing species occupy the exact same space perfectly
(D) One species completely eradicates the other within a day

2005

286. What does a "Type III survivorship curve" on a life table indicate about a nematode population?
(A) Low juvenile mortality, high adult mortality
(B) High early mortality with long lifespan for survivors
(C) Constant mortality across all ages
(D) Zero mortality

2022

287. Which soil characteristic provides the most ideal environment for the extensive movement and multiplication of root-knot nematodes?
(A) Heavy, compacted clay
(B) Completely waterlogged muck
(C) Solid bedrock
(D) Coarse, well-aerated sandy soil with adequate moisture

2021

288. The most significant advantage of calculating the Maturity Index (MI) is that it provides a quantitative measure of:
(A) The exact age in days of a specific nematode
(B) The precise tonnage of organic carbon in the soil
(C) Environmental disturbance and ecosystem successional status
(D) The exact dosage of nematicide required

2022

289. Which variable in the exponential growth formula ($N_t = N_0 e^{\{rt\}}$) dictates the intrinsic speed of population growth under ideal conditions?
(A) N_t
(B) r
(C) e
(D) N_0

2017

290. Anthropogenic disruption of soil, such as heavy rotary tillage, most directly and negatively impacts which nematode group?
(A) Small bacterivores (c-p 1)
(B) Large, k-selected omnivores and predators (c-p 4 and 5)
(C) Root-knot nematode eggs
(D) Cyst nematode cysts

NODIA

2025

291. Which of the following is a primary characteristic of a competitive (c-p 2) nematode?
(A) It forms cysts
(B) It requires a completely stable, undisturbed environment
(C) A microbivore maintaining stable populations under moderate fluctuation
(D) It is a massive apex predator

2024

292. The phenomenon of "dauer larva" formation in bacterivorous nematodes is primarily an ecological response to:
(A) Abundant food
(B) High oxygen levels
(C) Overcrowding and depletion of food resources
(D) Extreme cold

2017

293. Which primary morphological change occurs in female sedentary endoparasites as an adaptation to their lifestyle?
(A) Bodies swell to a globose shape for massive egg production
(B) They grow massive wings

(B) Purpureocillium lilacinum
(C) Arthrobotrys dactyloides
(D) Meloidogyne hapla

2007

271. In terms of nematode biomechanics, what restricts movement in extremely dry soils (below permanent wilting point)?
(A) The air in the pores becomes toxic
(B) The nematodes instantly freeze
(C) The soil pH drops drastically
(D) Thin water films fail to provide leverage for propulsion

2003

272. Why do K-strategist nematodes have high c-p values (4 or 5)?
(A) They reproduce rapidly in disturbed soils
(B) They are sensitive to disturbance and have long generation times
(C) They are obligate plant parasites
(D) They exclusively form cysts

2015

273. The primary ecological benefit of synchronized hatching in response to specific root exudates is:
(A) Preventing the juveniles from ever finding a host
(B) Maximizing infection success by emerging when host is present
(C) Maximizing exposure to winter frosts
(D) Allowing the nematode to instantly turn into a predator

2008

274. What is the defining characteristic of a strictly omnivorous nematode?
(A) It feeds only on other nematodes
(B) It requires a living plant root to survive
(C) It absorbs dissolved atmospheric carbon
(D) It derives nutrition from multiple diverse trophic levels

2010

275. How does the presence of a strong temperature gradient affect nematode movement (thermotaxis)?
(A) Nematodes migrate toward their species-specific thermal optimum
(B) Nematodes generally move randomly regardless of temperature
(C) Nematodes always move toward the hottest area available
(D) Nematodes always move toward freezing temperatures

2022

276. The calculation of net reproductive rate (R_0) from a life table indicates:
(A) The exact lifespan of the nematode
(B) The rate of movement through the soil
(C) Average female offspring produced by a female in her lifetime
(D) The percentage of males in the population

2007

277. Which ecological niche does the nematode genus Xiphinema occupy?
(A) Migratory ectoparasite
(B) Migratory endoparasite
(C) Sedentary endoparasite
(D) Omnivorous predator

2004

278. Which survival mechanism is generally utilized by nematodes to survive freezing temperatures?
(A) Anhydrobiosis
(B) Anoxybiosis
(C) Osmobiosis
(D) Cryobiosis

2011

279. The term "EIL" represents the point at which:
(A) The crop is completely dead
(B) Monetary yield loss equals the cost of control measures
(C) The initial nematode population is zero
(D) The nematicide begins to break down

2005

280. What indicates a high "Structure Index" (SI) in a soil nematode faunal analysis?
(A) A high abundance of fast-reproducing c-p 1 nematodes
(B) A complete lack of organic matter
(C) High abundance of large, slow-reproducing omnivores and predators
(D) Only plant-parasitic nematodes being present

2011

281. The primary driver of seasonal fluctuations in nematode populations in agricultural fields is:
(A) The lunar cycle
(B) The migration of wild mammals
(C) Uniform yearly rainfall
(D) Cyclical host growth combined with seasonal temperature changes

2009

282. Which of the following mathematical models incorporates a variable for carrying capacity (K)?

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ANSWERS

1. (B) The study of nematode interactions with their biotic and abiotic environment
Nematode ecology examines how these microscopic roundworms interact with both living organisms and non-living elements in their habitat. This field focuses on soil food web dynamics, nutrient cycling, and environmental factors rather than purely genetic classification or chemical control methods. Understanding these relationships helps manage agricultural pests and monitor overall soil health effectively.

2. (D) Bacterivores
Bacterivorous nematodes feed specifically on bacteria, which plays a critical role in regulating bacterial populations. By consuming bacteria, these nematodes release excess nitrogen held within bacterial cells back into the soil matrix. This process significantly enhances nitrogen mineralization, making this essential nutrient readily available to plants and driving overall soil nutrient cycling.

3. (A) It enters the root, establishes a specialized feeding site, and remains immobile
Sedentary endoparasites exhibit a specialized parasitic strategy where infective juveniles enter the host root tissue. Once inside, they inject salivary secretions to establish a permanent, complex feeding site, such as giant cells or syncytia. After initiating this site, the nematodes swell, lose their mobility, and remain completely stationary for the rest of their lifecycle.

4. (C) A horizon (rhizosphere)
The rhizosphere within the A soil horizon contains the highest concentration of plant roots, organic matter, and active microorganisms. Because plant-parasitic nematodes depend directly on living root tissue for food and energy, their populations are naturally most dense in this zone. This organic-rich layer provides optimal moisture, oxygen, and nutrient conditions for their survival.

5. (A) The thickness of the water film surrounding soil particles
Nematodes are essentially aquatic organisms that require a thin film of water surrounding soil particles to move. This liquid layer provides the hydrostatic pressure and surface tension necessary for their undulatory sinusoidal movement. If the film is too thin or completely floods the pore space, their physical leverage and active locomotion are severely restricted.

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6. (D) Transport via irrigation water or moving surface water
While nematodes actively crawl short distances through soil pores, their passive long-distance dispersal relies heavily on external forces. Surface run-off, irrigation water, and flooded waterways transport nematodes and their eggs across large distances and between different fields. This hydrological movement represents a primary pathway for spreading agricultural infestations rapidly across vast geographic areas.

7. (B) Penetrating host cell walls and withdrawing nutrients
The specialized, hollow stylet is a defining evolutionary adaptation of plant-parasitic nematodes. It functions like a microscopic hypodermic needle, allowing the nematode to mechanically pierce tough plant cell walls. Once inside the cell, the stylet is used to inject esophageal secretions that modify host tissues and subsequently withdraw liquefied nutrients for digestion.

8. (C) Anhydrobiosis
Anhydrobiosis is a remarkable physiological adaptation that allows soil nematodes to survive near-complete desiccation. When soil moisture levels drop catastrophically, the nematode slowly dehydrates, coiling its body to minimize surface area. It enters a state of suspended animation with undetectable metabolic activity, remaining viable until water returns to safely revive its biological functions.

9. (D) Rapid population build-up in the absence of mating males
Parthenogenetic reproduction enables female nematodes to produce viable offspring without requiring fertilization by males. This asexual strategy allows a single colonizing individual to rapidly establish and expand a population on a

2024

247. The "Damage Threshold" varies significantly between crops primarily due to:
(A) Differences in soil pH
(B) Differences in host plant tolerance and susceptibility to damage
(C) The color of the roots
(D) Differences in nematode movement speed

2003

248. The most ecologically relevant measure of soil moisture for nematodes is:
(A) Total weight of water in the field
(B) Volumetric water content
(C) Soil water potential determining moisture film thickness
(D) Annual rainfall average

2018

249. Which of the following anatomical structures is vital for the chemical orientation (chemotaxis) of nematodes toward root exudates?
(A) The median bulb
(B) The spicules
(C) The excretory pore
(D) Phasmids and amphids

2018

250. The mathematical equation for exponential population growth assumes:
(A) Constant and unlimited resources
(B) Severe limitation of resources from day one
(C) Zero births
(D) A carrying capacity of 100

2002

251. A nematode surviving anoxybiosis relies primarily on:
(A) Photosynthesis
(B) Glycolysis and fermentation pathways
(C) Aerobic respiration
(D) Absorbing oxygen directly from minerals

2022

252. Which nematode genus is most commonly associated with "spreading decline" in citrus?
(A) Meloidogyne
(B) Radopholus
(C) Pratylenchus
(D) Heterodera

2012

253. Which characteristic differentiates a fungivorous nematode's stylet from a plant-parasitic nematode's stylet?
(A) Fungivorous stylets are small, delicate, and lack basal knobs
(B) Fungivorous stylets are typically larger and heavily knobbed
(C) Fungivorous stylets are made of calcium
(D) Fungivorous stylets are located in the tail

2021

254. When the nematode density (P_i) is exactly equal to the Tolerance limit (T) in the Seinhorst model, the relative yield (y) is:
(A) 0
(B) 0.5
(C) 1.0 (or 100%)
(D) Equal to the minimum yield (m)

2003

255. High soil compaction generally affects nematode populations by:
(A) Increasing oxygen diffusion rates
(B) Stimulating rapid exponential growth
(C) Causing immediate molting
(D) Reducing pore space and restricting movement of larger species

2022

256. What is the fundamental role of "evenness" in evaluating nematode biodiversity?
(A) It accounts for the physical mass of the species
(B) It measures the exact length of the nematodes
(C) It quantifies the population equality of different species
(D) It determines the total number of species present

2010

257. Example of an anthropogenic mechanism of passive nematode dispersal is:
(A) Movement via irrigation canals
(B) Global transport of infected seed potatoes and nursery stock
(C) Wind blowing dry soil
(D) Migration of aquatic birds

2004

258. What physiological adaptation allows nematodes to survive high osmotic stress (osmobiosis)?
(A) Rapidly excreting all internal water
(B) Shedding the cuticle completely
(C) Increasing the heart rate
(D) Accumulating solutes to balance external osmotic pressure

2001

259. What happens to a nematode community immediately following the application of a broad-spectrum fumigant?

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19. (A) A carrying capacity (K) that limits maximum population size
The logistic growth model provides a realistic representation of population dynamics by incorporating environmental resistance. Unlike the exponential model, which assumes unlimited resources, the logistic model includes a carrying capacity parameter. This variable represents the maximum population size that the environment can support, causing growth to slow and stabilize as resources become depleted.

20. (B) I, II and IV
The Seinhorst model mathematically describes the relationship between initial plant-parasitic nematode density and relative crop yield. This model assumes that crops possess a tolerance limit below which no damage occurs, and uses an exponential decay curve to describe yield loss above this threshold. It is designed specifically for parasitic interactions rather than free-living bacterivores.

21. (A) Control measures should be initiated to prevent reaching the EIL
The Economic Threshold Level is a critical decision-making index in integrated pest management. It represents the specific nematode population density at which management actions must be implemented. Initiating control measures at this threshold prevents the growing nematode population from reaching the Economic Injury Level, where the cost of crop damage exceeds the cost of treatment.

22. (D) Short-lived, opportunistic bacterivores reproducing rapidly
On the colonizer-persister scale, nematodes with a value of one are classified as enrichment opportunists. These organisms are typically short-lived, small bacterivores with high reproductive rates and short generation times. They possess a high tolerance for environmental disturbances and respond explosively to sudden pulses of organic matter and bacterial blooms in the soil.

23. (B) An increase in environmental disturbance or stress
The Maturity Index measures the successional status of a soil nematode community based on their sensitivity to stress. A decrease in this index indicates that sensitive, long-lived persister nematodes with high colonizer-persister values are declining. This shift leaves the community dominated by opportunistic, highly tolerant species, reflecting elevated environmental disturbance, pollution, or physical stress.

24. (C) Enrichment Index
The Enrichment Index is a key diagnostic tool used to assess the nutritional status of the soil food web. It measures the relative abundance of opportunistic, fast-reproducing bacterivorous and fungivorous nematodes. A high index indicates a rapid influx of primary, easily decomposable organic resources, which fuels bacterial blooms and subsequently drives the opportunistic nematode population.

25. (A) P-4, Q-1, R-2, S-3
Diversity indices evaluate different community characteristics. The Shannon-Weaver Index combines species richness and relative abundance into an information-theoretic value. Simpson's Index calculates species dominance based on probability. Species richness counts the total unique species, while evenness describes the distribution of individuals among those species. These metrics collectively provide a comprehensive view of community structure.

26. (A) Carbon and energy flow through soil micro-food webs
Nematode ecology centers on understanding the complex flow of carbon and energy through soil micro-food webs. Because nematodes occupy diverse trophic positions, they act as critical intermediaries, consuming microbes, fungi, plants, and other fauna. Tracking these energetic pathways reveals how nutrients are mineralized, cycled, and transferred across different biological components within the soil ecosystem.

27. (B) Dorylaimida
Soil nematodes belonging to the taxonomic order Dorylaimida are typically characterized by their large bodies, complex feeding structures, and diverse diets. Many species within this group function as generalist omnivores, feeding on bacteria, fungi, algae, and small soil invertebrates. Their trophic flexibility and sensitivity to environmental changes make them important indicators of soil ecosystem health.

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28. (B) Pratylenchus penetrans
Pratylenchus penetrans, commonly known as the root-lesion nematode, is a classic representative

region containing the feeding structures remains permanently embedded in the root cortical or vascular tissue to extract nutrients throughout their life.

65. (A) P-4, Q-1, R-2, S-3
Nematodes possess specific adaptations linked to critical survival functions. Dauer larvae survive severe environmental stress through metabolic arrest. Modified stylets allow plant-parasitic species to penetrate tough host cell walls. Cuticular annulations provide the body flexibility needed for locomotion through soil pores. Synchronized hatching ensures that emerging juveniles coincide with active host root growth.

66. (D) Climate patterns and host plant distribution
The global geographic distribution of major nematode biomes is primarily shaped by broad climate patterns and host plant availability. Temperature and precipitation dictate soil moisture, vegetation types, and plant growth seasons. Because many nematode species are obligate parasites or associated with specific rhizosphere communities, their ranges are closely aligned with these environmental and botanical limits.

67. (A) Intra-specific competition for limited root resources
Density-dependent factors regulate population growth based on the number of individuals in a given area. Intra-specific competition for limited feeding sites and nutrients within host roots is a classic negative density-dependent mechanism. As nematode density increases, resources become depleted, reducing individual feeding rates, slowing juvenile development, and lowering overall fecundity within the population.

68. (C) The maximum sustainable population size in an environment
Carrying capacity is a fundamental ecological concept that defines the maximum population size of a species that a specific environment can support. In soil systems, this limit is determined by the availability of food resources, such as host plant roots or microbial prey, and habitable pore space. It acts as the upper limit in logistic growth models.

69. (A) The minimum relative yield obtained at maximum nematode density
In the Seinhorst damage model, the parameter m represents the minimum relative crop yield. This variable defines the residual yield obtained even under extremely high initial nematode densities, where further increases in parasite numbers no longer cause additional damage. It reflects the plant's capacity to produce a basic minimum yield despite severe root parasitism.

70. (B) II, IV and V
Nematode community indicators reflect soil food web status. The Enrichment Index increases with organic inputs as bacterivores multiply. The Structure Index correlates with complex food webs containing sensitive persister nematodes. A high Maturity Index reflects undisturbed, stable climax ecosystems. However, bacterivores have low colonizer-persister values, whereas persisters are highly sensitive to disturbances.

71. (B) Spatial separation on different root zones or depths
Niche partitioning is an evolutionary mechanism that minimizes competitive exclusion among co-occurring plant-parasitic nematode species. On a single host plant, different species often adapt to target specific spatial zones. For example, some species feed exclusively on root tips, while others inhabit mature cortical tissues or occupy different soil depths, allowing them to coexist.

72. (C) Collembola and mesostigmatid mites
Soil microarthropods, particularly collembolans and mesostigmatid mites, are significant natural predators of soil nematodes. These tiny invertebrates actively hunt and consume various nematode trophic groups within the soil pore network. Their predatory activities exert important top-down control on nematode populations, contributing to biological suppression and maintaining structural balance within the soil food web.

73. (D) Shannon-Weaver Index
The Shannon-Weaver Index is a widely used mathematical metric in community ecology that measures species diversity. It is uniquely valuable because it simultaneously evaluates both species richness, which is the total number of species, and species evenness, which is their relative abundance. This combination provides

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optimum slow down development or trigger survival mechanisms like dormancy to escape thermal stress.

38. (D) Altering mineral solubility and microbial activity
Soil pH is a critical abiotic factor that primarily influences nematode communities indirectly. It directly affects the solubility of essential plant nutrients and toxic metals, which alters host root growth and exudation patterns. Additionally, soil pH shapes the abundance and composition of microbial populations, thereby modifying the food availability for bacterivorous and fungivorous nematodes.

39. (B) Chemotaxis
Chemotaxis is the biological process where nematodes detect and orient their movement along chemical concentration gradients. Host plant roots continuously release complex exudates, including carbon dioxide, sugars, and amino acids. Plant-parasitic nematodes use specialized sensory organs called amphids to perceive these chemical signals, guiding them directly toward the susceptible zones of growing roots.

40. (A) II, IV, I, III
The infection process of Pasteuria penetrans begins when motile nematodes contact bacterial endospores, which attach firmly to their cuticle. The spore then germinates, penetrating the nematode cuticle with an infection tube to enter the pseudocoelom. Once inside, the bacteria proliferate vegetatively, eventually producing millions of new endospores that are released back into the soil.

41. (D) Antagonistic interactions reducing feeding sites
Concomitant infection of a host root system by Meloidogyne and Pratylenchus typically triggers intense competition for limited spatial and nutritional resources. This interaction is generally antagonistic, as the feeding activities of one species can damage root tissues and disrupt the vascular changes required by the other. Consequently, this competition reduces the available feeding sites for both populations.

42. (A) The age-specific survival rate or proportion surviving to age x
In demographic life tables, the parameter designated as l_x represents the age-specific survival rate. It measures the probability that an individual within a specific cohort will survive from birth to the start of age x. This metric is critical for calculating age-specific life expectancy and understanding the mortality patterns of nematode populations under varying conditions.

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43. (B) The formation of dauer larvae or environmentally resistant eggs
Overwintering in temperate environments requires nematodes to survive prolonged periods of freezing temperatures and food scarcity. Many species facilitate survival by forming specialized, physiologically resistant stages. These include arrested dauer larvae or thick-shelled eggs containing high levels of protective sugars. These dormant structures protect internal cellular integrity until favorable spring conditions trigger reactivation.

44. (B) Intrinsic rate of increase
In the classical exponential growth equation, the variable r represents the intrinsic rate of natural increase. It is a mathematical constant that defines the maximum potential growth speed of a population per individual under ideal, unlimited environmental conditions. This rate is determined by the balance between birth and death rates in the absence of density-dependent constraints.

45. (A) Both A and R are true and R is the correct explanation of A.
In the Seinhorst damage model, the Tolerance Limit represents the initial nematode density below which crop yield remains completely unaffected. This threshold exists because plants possess active compensatory growth mechanisms, such as root regeneration and enhanced metabolic efficiency. These physiological responses effectively offset minor cellular damage caused by low densities of plant-parasitic nematodes.

46. (C) Higher than or equal to the Economic Threshold Level (ETL)
The Economic Injury Level represents the lowest nematode density that will cause economic damage equal to the cost of control. To prevent populations from reaching this damaging level,

The process requires mechanical thrusting of the hollow stylet, driven by powerful esophageal muscles, to physically weaken the cell wall. Simultaneously, the nematode secretes cell-wall-degrading enzymes, such as cellulases and pectinases, from its esophageal glands to chemically liquefy host structures, facilitating entry.

84. (C) Bacterivorous nematodes
Bacterivorous nematodes are morphologically characterized by a wide, unarmed stoma that is typically cup-shaped or cylindrical. Lacking a stylet or teeth, these organisms feed by drawing liquid suspension containing bacteria into their buccal cavity. The bacteria are then crushed in the muscular esophageal bulb, allowing these nematodes to process massive bacterial populations efficiently.

85. (A) Both A and R are true and R is the correct explanation of A.
The Shannon-Weaver Index is a single mathematical value that merges species richness and species evenness. Because it combines these two distinct ecological properties, relying solely on this index can obscure the underlying driver of diversity shifts. For example, a change in evenness could offset a drop in richness, yielding an identical index value.

86. (D) $y = m + (1 - m)z^{\{P-T\}}$
The classic Seinhorst equation models relative crop yield as a function of initial nematode density. When the initial density exceeds the plant's tolerance limit, the relative yield is expressed as a minimum yield plus a variable term that decays exponentially with the excess nematode population, using the base constant z, representing the plant's damage response.

87. (B) Recovery of complexity and presence of persister nematodes
An increase in the Structural Index of a soil nematode community indicates the recovery and maturation of the soil food web. This index reflects the relative abundance of long-lived, high-c-p omnivores and predators. A high index signifies a complex, stable ecosystem that has recovered from disturbance, supporting multiple trophic layers and balanced biological interactions.

88. (C) By undulatory propulsion against soil particles
Nematodes navigate the complex, tortuous path of soil pore spaces using undulatory propulsion. This sinusoidal movement is generated by alternating contractions of dorsal and ventral longitudinal muscles. This wave-like motion pushes the nematode's body against solid soil particles and water films, creating the forward thrust needed to glide through the soil matrix.

89. (D) A large tooth or a heavily armed buccal cavity
Predatory nematodes like Discolaimus are morphologically adapted for a carnivorous lifestyle. They typically possess a large, open stoma armed with a prominent tooth, stylet, or cutting plates. These specialized structures are used to seize, pierce, or ingest other soil invertebrates and nematodes, distinguishing them from microbivorous species that feed on suspended bacteria.

90. (B) I and III
Host finding in soil nematodes is a highly regulated process driven by chemical signals. Repellent compounds in root exudates from non-host plants can deter incompatible nematodes, while carbon dioxide gradients produced by root respiration provide critical long-distance cues for orientation. Nematodes do not find roots randomly, but instead navigate precisely along these biochemical gradients.

91. (B) Temperature variations and host plant growth cycles
Seasonal population fluctuations of soil nematodes in temperate climates are primarily driven by temperature variations and host plant development. Warm temperatures accelerate metabolic activity, development, and reproduction, while actively growing host crops provide abundant food resources. In contrast, cold winter temperatures and host dormancy trigger population declines, forcing nematodes into survival states.

92. (B) The Allee effect
The Allee effect is an ecological phenomenon where a population's per capita growth rate declines at very low densities. In soil nematodes, low density makes it physically difficult for mobile males and females to locate each other within the vast soil matrix. This reduced mating

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restricts active locomotion, habitat colonization, and host-seeking behavior, highlighting how soil compaction directly limits nematode distribution.

56. (C) Movement of contaminated soil on farm machinery and tools
Anthropogenic activities are the primary drivers of rapid, long-distance dispersal of plant-parasitic nematodes. Because nematodes move slowly on their own, the transport of contaminated soil adhering to farm machinery, tillage tools, and vehicles facilitates passive dispersal. This human-mediated pathway introduces devastating agricultural pests into previously uninfested fields and regions with great efficiency.

57. (D) Synthesis of effectors injected into host cells
Sedentary endoparasitic nematodes possess highly developed esophageal glands, which are crucial for establishing successful parasitic relationships. These glands synthesize specialized effector proteins and cell-wall-degrading enzymes. Using their stylet, the nematodes inject these molecular effectors directly into host plant cells, suppressing plant defense mechanisms and driving the complex development of specialized, nutrient-rich feeding sites.

58. (A) Self-fertilization, ensuring reproduction even when isolated
Hermaphroditism is a highly efficient reproductive strategy observed in certain nematode species like Caenorhabditis elegans. It allows individual organisms to self-fertilize, producing viable offspring without needing to locate a mating partner. This capability ensures successful reproduction and rapid population establishment even when a single individual becomes physically isolated in a new, unoccupied soil microhabitat.

59. (B) Protect the eggs from desiccation and microbial attack
Root-knot nematode females secrete a specialized gelatinous matrix from their rectal glands to encase their eggs. This matrix forms a protective envelope that serves multiple critical ecological functions. It acts as a physical and chemical barrier, preventing the eggs from drying out in arid soils and shielding them from soil-borne pathogens, predators, and fungal attack.

60. (B) I, III and IV
Soil physical properties strongly govern nematode biology. Nematode activity peaks at field capacity where water and air are balanced, while soil compaction reduces pore spaces and restricts movement. Additionally, coarse sandy soils exhibit a lower water holding capacity than clay soils. However, oxygen consumption is highly temperature-dependent, as metabolic rates rise with temperature within physiological limits.

61. (A) Feeds on a diverse diet that may include bacteria, algae, fungi, and other microorganisms
Omnivorous soil nematodes occupy a broad ecological niche due to their highly diverse feeding habits. Unlike specialized parasites or microbivores, omnivores possess complex feeding structures that allow them to ingest a wide variety of food sources. Their diet typically includes bacteria, fungi, algae, protists, and small soil invertebrates, linking multiple trophic pathways.

62. (C) Second-stage juvenile (J2)
The second-stage juvenile is the critical infective and dispersal phase of the root-knot nematode life cycle. After hatching from the egg in the soil, the mobile J2 must actively navigate through soil pores toward host roots. This stage possesses the sensory and physical adaptations necessary to locate, penetrate, and colonize host tissues to initiate infection.

63. (D) High solute concentrations in the surrounding soil solution
Osmobiosis is a specialized survival strategy triggered when nematodes experience extreme osmotic stress. This condition occurs in soils with very high solute concentrations, such as saline soils or environments heavily treated with chemical fertilizers. To survive, the nematode alters its membrane permeability and accumulates internal solutes, preventing lethal water loss to the hypertonic surroundings.

64. (C) Having its anterior portion embedded in host tissue
Semi-endoparasitic nematodes exhibit a transitional feeding strategy between ectoparasitism and endoparasitism. During infection, these nematodes penetrate the host root only partially, leaving their posterior body portion exposed to the soil matrix. The anterior

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the Economic Threshold Level is established as a lower action threshold. Therefore, the Economic Injury Level is mathematically and practically always higher than or equal to the Economic Threshold Level.

47. (D) Are highly sensitive to stress and have long generation times
On the colonizer-persister scale, dorylaimid nematodes receive high scores of four or five due to their K-selected life history traits. These organisms possess large bodies, long lifespans, low reproductive rates, and extended generation times. They are exceptionally sensitive to physical disturbances, chemical pollution, and environmental stress, making them excellent indicators of stable, undisturbed soil ecosystems.

48. (C) Plant-parasitic nematode families
The Plant Parasitic Index is a structured environmental metric calculated using the same mathematical framework as the Maturity Index. However, while the Maturity Index focuses exclusively on free-living taxa, the Plant Parasitic Index is calculated using only plant-parasitic nematode families. This distinction helps monitor how agricultural practices specifically affect the parasitic components of the soil community.

49. (B) The balance between bacterial and fungal decomposition pathways
The Channel Index is a vital diagnostic tool used in soil food web analysis. It quantifies the relative importance of fungal versus bacterial decomposition pathways in the soil. A high index indicates that the soil organic matter is being decomposed primarily by fungi, whereas a low index reflects a bacterial-dominated decomposition channel, indicating differing nutrient cycling speeds.

50. (A) I and II
Species richness represents the basic count of unique species identified within a community, while evenness measures how equally distributed individuals are among those species. The Shannon-Weaver Index is an information-theoretic metric that mathematically integrates both species richness and evenness into a single value, rather than ignoring evenness, to describe overall community diversity.

51. (A) Top-down regulation of other nematode populations
Predatory nematodes, such as Mononchus, play a vital ecological role as carnivores in the soil food web. By preying on other nematodes, including plant-parasitic and microbivorous species, they exert top-down regulation on soil populations. This predatory activity prevents individual species from reaching damaging densities, maintaining biological balance and supporting complex, stable soil communities.

52. (C) Massive accumulation of trehalose to stabilize cell membranes
Anhydrobiosis is enabled by complex physiological adaptations that protect cellular components from desiccation. In response to drying, nematodes synthesize and accumulate massive amounts of trehalose, a non-reducing disaccharide. Trehalose replaces water molecules around proteins and lipids, stabilizing cell membranes and preventing macromolecular denaturation, allowing the organism to safely remain in a dormant state.

53. (A) The outermost epidermal cells and root hairs while remaining outside the root
Migratory ectoparasites represent a distinct trophic category of plant-parasitic nematodes. These organisms spend their entire life cycle in the soil matrix outside the plant host. They feed by inserting their long stylets into root hairs and outermost epidermal cells, sucking out cellular contents without ever entering the protective internal root tissues themselves.

54. (D) Aggregated or patchy
In agricultural fields, the spatial distribution of nematodes is rarely uniform or random; instead, it is characteristically aggregated or patchy. This clumped pattern is driven by their slow active locomotion, localized host plant roots, and point-source introductions. Consequently, high-density hot spots are separated by areas of low nematode density, complicating soil sampling and management.

55. (B) Smaller than the nematode's body diameter
Nematode movement through the soil matrix is physically constrained by the pore neck diameters. When soil pore diameters are smaller than the nematode's body diameter, the organism cannot physically pass through the channels. This structural barrier severely

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a sensitive indicator of ecological stability and community structure.

74. (A) Lack of oxygen
Anoxybiosis is a specialized metabolic survival strategy triggered by complete oxygen deprivation, commonly occurring in waterlogged or heavily compacted soils. In response to anaerobic conditions, nematodes halt aerobic respiration, movement, and development, switching to inefficient anaerobic glycolytic pathways. This state allows them to survive prolonged flooding until normal oxygen levels are restored.

75. (A) Egg → J1 → J2 → J3 → J4 → Adult
The standard lifecycle of nematodes is highly conserved and consists of six distinct developmental stages. It begins with the egg, followed by four juvenile stages designated as J1, J2, J3, and J4, which are separated by successive cuticular molts. The final molt transitions the J4 stage into the mature, reproductively active adult male or female.

76. (B) The density where statistically significant yield loss begins
Determining the Damage Threshold is vital for effective crop management and agricultural decision-making. This biological parameter represents the specific nematode population density at planting that begins to cause statistically significant crop yield loss. Identifying this threshold allows growers to evaluate whether pest control measures are economically justified to protect crop health.

77. (A) The field is heavily cultivated, favoring plant parasites
A soil profile exhibiting a high Plant Parasitic Index alongside a low Maturity Index for free-living species typically indicates a highly disturbed agricultural environment. Intensive cultivation and monoculture practices disrupt complex food webs, reducing sensitive persister species. This environmental disturbance selectively favors opportunistic free-living nematodes while providing abundant resources for crop-specific plant-parasitic species to thrive.

78. (C) Swollen body types like dauer larvae are highly active and feed aggressively
Nematodes possess diverse survival adaptations, but the assertion that dauer larvae feed aggressively is incorrect. The dauer stage is a non-feeding, metabolically arrested juvenile form adapted specifically to survive harsh environmental conditions and facilitate dispersal. These larvae seal their stoma, rely entirely on stored lipid reserves, and remain inactive until favorable conditions return.

79. (D) Dry, sandy soils in a state of anhydrobiosis
Wind-borne passive dispersal is most effective when agricultural soils are dry, loose, and sandy. Under drought conditions, nematodes entering a dormant state of anhydrobiosis become highly resistant to desiccation. Strong winds erode the dry surface soil, transporting the dormant nematodes and dust particles over vast distances, facilitating the colonization of new geographic regions.

80. (B) II, III, I
Under integrated pest management, ecological thresholds follow a strict hierarchy of ascending nematode densities. The Tolerance Limit is the lowest density, marking where damage first starts. The Economic Threshold Level is higher, representing the action threshold to prevent further population growth. The Economic Injury Level is the highest, where damage costs equal control costs.

81. (B) The birth rate or production of new offspring
In demographic and ecological life table analyses, the term natality refers to the birth rate or the production of new offspring within a population. It measures the reproductive output of a cohort, usually expressed as the number of eggs or viable juveniles produced per female over a specific interval, driving overall population growth.

82. (D) A gradient of CO2 and root exudates
Second-stage juveniles of root-knot nematodes locate host roots by following specific environmental gradients. Growing roots continuously respire, releasing carbon dioxide, and exude sugars and amino acids, establishing a concentration gradient in the rhizosphere. The J2s detect these chemical signals using their sensory amphids, guiding them directly toward the optimal root elongation zone.

83. (A) A combination of mechanical thrusting and enzymatic secretions
Nematodes penetrate tough plant cell walls using a coordinated biophysical mechanism.

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of migratory endoparasites. Unlike sedentary parasites, these nematodes retain their mobility throughout their entire life cycle. They continuously migrate through the root cortical tissues, feeding destructively on host cells and leaving necrotic lesions that severely compromise the plant's vascular and root systems.

29. (A) Host plant root mass and organic matter
The vertical distribution of nematodes within a soil profile is highly stratified and typically mirrors the abundance of plant roots and organic matter. Because these resources are concentrated in the upper soil horizons, particularly the rhizosphere, both plant-parasitic and free-living decomposer nematodes congregate there. Deeper soil layers support fewer nematodes due to reduced food availability.

30. (B) II and V
Nematodes lack circular muscles, relying instead on longitudinal muscles working against a high-pressure hydrostatic skeleton for movement. Additionally, they do not require water films thicker than their body diameter; optimal movement occurs when the water film is thin enough to compress the nematode against soil particles, providing the necessary leverage for efficient undulatory propulsion.

31. (D) Anguina tritici
Anguina tritici, the wheat seed gall nematode, utilizes seed-borne dispersal as its primary epidemiological mechanism. The infective juveniles enter the developing flower galls, dehydrate, and enter a state of anhydrobiosis inside the harvested grain. When these contaminated seeds are sown, the dormant nematodes rehydrate, emerge, and infect the new crop, facilitating long-distance transport.

32. (C) Accommodating massive egg production
The transition of sedentary endoparasitic females from a vermiform shape to an enlarged, swollen body is a highly specialized evolutionary adaptation. Because these females remain stationary inside or on the host root, they divert all metabolic energy toward reproduction. The swollen body physically accommodates the development of massive ovaries, allowing them to produce hundreds of eggs.

33. (B) Freezing temperatures
Cryobiosis is a specialized form of cryptobiosis triggered by extreme freezing temperatures. In response to freezing, nematodes synthesize ice-active proteins and intracellular protective solutes to prevent lethal ice crystal formation within their cells. This physiological state allows them to survive in frozen soils, protecting their cellular structures until environmental temperatures rise back to active levels.

34. (D) Infective juveniles emerge during active host growth
A highly synchronized hatching strategy triggered by host root exudates provides a major survival advantage for plant-parasitic nematodes. This adaptation ensures that dormant infective juveniles emerge into the soil only when actively growing host roots are present. This precise timing maximizes their chances of quickly finding a food source, preventing starvation and unsuccessful search efforts.

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35. (C) I, III, II
Soil particle size directly determines the size of the pore spaces created within the soil matrix. Fine clay particles pack tightly, creating the smallest pore spaces, followed by intermediate silt particles. Coarse sand particles generate the largest pore spaces. Consequently, the correct ascending order of pore space size is fine clay, silt, and coarse sand.

36. (C) Suffer severe osmotic stress and limit movement
When soil moisture drops to the permanent wilting point, the water potential becomes extremely low. Under these arid conditions, the thin water films surrounding soil particles disappear, exposing nematodes to severe osmotic stress and dehydration. This physical lack of liquid water deprives them of the hydrostatic leverage needed for locomotion, halting their movement entirely.

37. (A) It is the temperature range where reproduction and development are maximized
The thermal optimum for a plant-parasitic nematode species represents the specific temperature range where its physiological processes are most efficient. Within this range, metabolic activity, locomotion, feeding, development, and reproductive rates are maximized. Temperatures above or below this

success leads to lower reproductive rates, potentially causing small populations to crash.

93. (A) Movement is restricted due to small pore neck diameters
Extremely fine soil textures, such as heavy clay, create highly compacted pore networks with tiny neck diameters. Large nematodes like Xiphinema require relatively large channels for physical passage. Because clay pores are significantly smaller than their body width, these large nematodes are physically trapped and restricted in their movement, limiting their distribution in clay-dominated soils.

94. (C) Opportunistic bacterivores (c-p 1)
The intrinsic rate of natural increase is highest for opportunistic bacterivorous nematodes, which are assigned a value of one on the colonizer-persister scale. These r-selected organisms possess short life cycles, high fecundity, and rapid development rates. This combination allows them to multiply explosively in response to sudden bacterial blooms, outcompeting slower-growing predatory or parasitic species.

95. (D) An arrested survival stage adapted for dispersal
The dauer juvenile is a specialized, non-feeding developmental stage that is ecologically vital for survival. Triggered by harsh environmental conditions, food scarcity, or overcrowding, the dauer stage exhibits high resistance to desiccation and heat. It serves as an arrested survival form adapted for dispersal, allowing nematodes to survive adverse conditions and colonize new habitats.

96. (C) Tillage and mechanical soil disruption
Density-independent regulators are environmental factors that affect populations regardless of their density. Physical agricultural practices, such as mechanical tillage, are classic density-independent factors. Tillage physically disrupts the soil matrix, damages delicate nematodes, alters pore structures, and exposes organisms to rapid drying, causing significant mortality across both high and low density populations.

97. (B) Two or more nematode species infect the same host simultaneously
Concomitant infection refers to the ecological scenario where two or more distinct plant-parasitic nematode species colonize and infect the same host plant root system at the same time. This coexistence triggers complex interspecific interactions, which may range from spatial resource partitioning to severe competitive antagonism, directly influencing overall disease severity and crop damage.

98. (D) Enter anhydrobiosis or seek deeper soil layers
Oversummering in hot, arid climates exposes soil nematodes to extreme heat and desiccation in upper soil layers. To survive, nematodes must adapt by entering a dormant state of anhydrobiosis to resist water loss. Alternatively, they migrate vertically down the soil profile to deeper, cooler, and more humid layers where moisture and active root systems remain available.

99. (A) Economic justification for nematicide application
The Tolerance Limit is a valuable parameter for agricultural management. By identifying the nematode density below which no yield loss occurs, farmers can determine whether pest populations pose a genuine threat. This threshold helps establish economic justification for applying chemical nematicides, preventing unnecessary and costly treatments when nematode densities are too low to cause damage.

100. (A) I and II
Hermaphroditic nematode species possess both male and female reproductive organs, allowing them to produce sperm and oocytes for self-fertilization. Amphimictic species rely on sexual reproduction, requiring active mating between males and females to produce viable eggs. In contrast, parthenogenetic species reproduce without mating, and males are rare or non-functional in their populations.

101. (A) High species diversity with no single dominant species
Simpson's Index measures species dominance within a community. A low index value indicates that dominance is low, meaning that individuals are distributed relatively evenly among many different species. This structure represents a highly diverse community where no single opportunistic species dominates numerically, indicating a stable and balanced soil ecosystem with complex ecological relationships.

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102. (D) Species feeding on different tissue types
Niche partitioning allows multiple nematode species to exploit the same host plant while minimizing competitive exclusion. When different species target distinct tissues—such as one species feeding exclusively on root cortical cells while another targets vascular tissue—they reduce direct resource competition. This spatial and physiological separation allows both populations to coexist on the host.

103. (B) To coordinate its life cycle with the favorable host period
Diapause is a genetically programmed, physiological state of developmental arrest. Unlike immediate quiescence, it is triggered by seasonal environmental cues to ensure that active life stages emerge when host plants are growing and resources are abundant. This temporal synchronization coordinates the nematode's life cycle with host availability, maximizing reproductive success and survival.

104. (C) The international trade of bare-root nursery stock
International trade of agricultural materials is a major anthropogenic mechanism for the global spread of plant-parasitic nematodes. Bare-root nursery stock, seedlings, and root crops often harbor microscopic nematodes in adhering soil or root tissues. Transporting these plant materials across borders introduces invasive nematode species into new regions, bypassing natural geographical barriers.

105. (A) P-2, Q-4, R-3, S-1
Nematode groups exhibit distinct feeding behaviors. Ectoparasites feed on root surfaces while remaining entirely in the soil. Endoparasites enter host tissues to complete their life cycles. Bacterivores ingest bacteria through a tubular stoma, while predators utilize teeth or specialized stylets to capture and consume small soil invertebrates. These differences define their functional roles in soil webs.

106. (A) Large body size, long lifespan, and low reproductive rate
In population ecology, K-strategists are characterized by adaptations suited for stable, predictable environments near carrying capacity. These nematodes typically exhibit large body sizes, long lifespans, and low reproductive rates. They invest significant energy in individual survival and offspring viability rather than rapid multiplication, making them highly sensitive to environmental disturbances and physical soil stress.

107. (B) Improving survival against biotic and abiotic stresses
The secretion of a gelatinous matrix around Meloidogyne eggs is a crucial evolutionary adaptation. This sticky, complex barrier encases the egg mass, protecting it from dehydration in dry soils. Additionally, it acts as a defensive shield against microbial pathogens, soil-borne predators, and fungal parasites, enhancing the long-term survival of the offspring.

108. (B) Infochemicals mediating attraction and hatching
Root exudates released by plants act as highly influential infochemicals in the rhizosphere. These complex biochemical mixtures contain sugars, amino acids, and specialized signaling compounds that nematodes detect. They serve as primary cues that guide plant-parasitic species toward host roots through chemotaxis and stimulate dormant eggs of specific cyst nematodes to hatch.

109. (A) Pasteuria penetrans
Pasteuria penetrans is a highly specialized, obligate bacterial parasite of plant-parasitic nematodes, particularly root-knot species. The bacterium survives in the soil as endospores that attach to the cuticle of migrating juveniles. It penetrates the nematode's body cavity, multiplying vegetatively and consuming internal organs, ultimately sterilizing the female and releasing new endospores upon host decay.

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110. (A) I and III
While extreme soil pH indirectly influences nematodes by altering host plant vigor and rhizosphere microbial communities, it does not directly kill all species, as many have wide tolerance ranges. Furthermore, most plant-parasitic species do not prefer highly alkaline soils, instead thriving in neutral to slightly acidic conditions where root growth and nutrient availability are optimal.

111. (D) Simpson's Index
Simpson's Diversity Index is a mathematical metric that measures the probability that two randomly selected individuals from a community

belong to the same species. Because it squares the relative abundance of each species, it mathematically places heavy weight on the dominance of the most common species, making it highly sensitive to changes in dominant taxa.

112. (C) Occupy almost every trophic level in the micro-fauna
Nematodes are central to the structure and function of the soil food web because they occupy almost every trophic level in the micro-fauna. They act as bacterivores, fungivores, plant parasites, omnivores, and predators. This trophic diversity allows them to influence multiple biological pathways, connecting microbial decomposers to higher predators and driving nutrient mineralization.

113. (B) A tightly coiled shape to reduce water loss
During the transition into anhydrobiosis, nematodes physically alter their morphology by coiling their bodies tightly into a spiral. This coiling behavior is a vital physical adaptation that minimizes exposed surface area. By reducing the surface-to-volume ratio, the nematode slows the rate of water loss, allowing protective sugars to accumulate and stabilize cellular membranes.

114. (D) Xiphinema
Nematodes within the genus Xiphinema, commonly known as dagger nematodes, are notorious vectors of plant viruses. During their ectoparasitic feeding process on root cells, these nematodes ingest viral particles along with host fluids. The virus particles adsorb to the lining of the nematode's esophagus and are subsequently transmitted to healthy plants during subsequent feeding events.

115. (A) Lack of host roots and reduced oxygen levels
The vertical distribution of soil nematodes is primarily restricted by the availability of food resources and essential oxygen. As soil depth increases, host plant roots and decomposing organic matter become scarce, starving parasitic and free-living species. Additionally, deeper soil horizons suffer from poor aeration and compaction, leading to reduced oxygen levels that limit aerobic respiration.

116. (C) Tylenchulus - Semi-endoparasite
Tylenchulus, particularly Tylenchulus semipenetrans, is a classic example of a semi-endoparasitic nematode. During its development, the female juvenile partially penetrates the host root tissue. The anterior portion of its body becomes permanently embedded in the cortical cells to feed, while the posterior portion remains exposed to the soil matrix, where it secretes gelatinous egg masses.

117. (A) A rapid multiplication of c-p 1 bacterivorous nematodes
Agricultural practices like tillage and fertilization trigger a rapid decomposition of organic matter, fueling a bacterial bloom. This massive increase in microbial biomass is quickly exploited by opportunistic, fast-reproducing bacterivorous nematodes. Because these organisms have low colonizer-persister values, their rapid population growth drives the Enrichment Index upward immediately after soil amendment.

118. (D) Nematophagous fungi and parasitic bacteria
Suppressive soils naturally limit the development of plant-parasitic nematode populations even in the presence of susceptible crops. This biological suppression is primarily driven by high densities of antagonistic microorganisms, including nematophagous fungi and parasitic bacteria. These natural enemies actively trap, infect, or parasitize nematodes and their eggs, maintaining pest populations below economic damage thresholds.

119. (B) The atomic mass of soil minerals
A demographic life table is designed to analyze the population dynamics and reproductive potential of a biological cohort. It compiles critical life-history data such as age-specific survival, fecundity, and life expectancy. Abiotic physical measurements, such as the atomic mass of soil minerals, are purely physical properties and are not included in biological life tables.

120. (C) Presence of a delicate stylet for hyphal piercing
Fungivorous nematodes are morphologically distinguished from bacterivorous species by the presence of a delicate, hollow stylet. These nematodes use this specialized structure to pierce the tough chitinous cell walls of fungal hyphae. Once the wall is breached, they inject digestive enzymes and withdraw the liquefied fungal contents, a feeding mechanism unavailable to broad-mouthed bacterivores.

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more rapid and severe vascular wilt symptoms than when either pathogen is alone.

196. (C) Increase the Shannon-Weaver Index
Species richness is a primary component of community diversity. In calculating the Shannon-Weaver Index, increasing the total number of unique species, while holding species evenness constant, mathematically increases the index value. This rise reflects a more complex, diverse community structure with a wider variety of ecological roles and niches within the soil ecosystem.

197. (A) Omnivores and diverse free-living fungivores/ bacterivores
The undisturbed O horizon of forest soils contains abundant leaf litter, decomposing organic matter, and diverse microbial communities. This nutrient-rich organic layer supports high populations of free-living bacterivores and fungivores that drive decomposition. Additionally, the lack of disturbance allows sensitive, high-c-p omnivores to thrive, resulting in a mature, complex nematode community.

198. (D) The gelatinous matrix secreted by the rectal glands
Overwintering eggs of Meloidogyne are protected from extreme cold and desiccation by a specialized gelatinous matrix. Secreted by the female's rectal glands, this complex barrier encases the egg mass outside the root tissue. It acts as a physical and chemical shield, preventing water loss and microbial invasion, ensuring juvenile survival until spring.

199. (B) Economic Threshold Level
In integrated pest management, the acronym ETL stands for the Economic Threshold Level. This parameter is a critical decision-making index representing the specific nematode population density at which management actions should be initiated. Implementing control measures at this threshold prevents growing pest populations from reaching the higher Economic Injury Level where financial damage occurs.

200. (C) Exponential model
The exponential population growth model assumes that resources are unlimited and environmental resistance is absent. Consequently, this mathematical model lacks a carrying capacity parameter, which represents the maximum population size an environment can support. In contrast, logistic and density-dependent models incorporate carrying capacity to describe realistic population stabilization as resources become depleted.

201. (D) They move through cortical tissues while laying eggs
Root-lesion nematodes, Pratylenchus spp., are migratory endoparasites because they retain complete mobility throughout their life cycle inside host tissues. They enter roots and move continuously through cortical cells to feed, causing cellular collapse and necrotic lesions. During this migration, they deposit eggs singly within the root cortex or the surrounding soil.

202. (A) A flexible cuticle allowing coiling and moisture retention
Surviving extreme desiccation through anhydrobiosis requires specific morphological adaptations. A highly flexible, specialized cuticle allows the nematode to coil its body tightly into a compact spiral. This coiling physical response minimizes the exposed body surface area, dramatically slowing the rate of water loss and enabling intracellular sugars to stabilize cell membranes.

203. (B) Below T, the crop suffers no economic damage
Assessing the Tolerance Limit is crucial before implementing pest control measures. Below this threshold, host plants utilize compensatory growth mechanisms to offset minor root damage, resulting in no detectable yield loss. Therefore, applying chemical nematicides when nematode densities are below the Tolerance Limit is economically unjustified, as there is no damage to prevent.

204. (B) Exhaustion of host root resources
Density-dependent factors regulate population growth based on density. The exhaustion of host root resources is a classic density-dependent mechanism. As nematode density rises, intense competition for feeding sites depletes nutrients, reducing individual growth, reproduction, and survival. Abiotic factors like drought, flooding, and tillage affect populations regardless of density.

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each species within a community. In this formula, p_i represents the proportion of individuals belonging to species i. Squaring these values places greater mathematical weight on highly abundant species, reflecting the probability that two randomly selected individuals will belong to the same taxon.

131. (A) They produce motile zoospores that seek out and infect nematodes
Catenaria anguillulae is a specialized zoosporic fungus that acts as an endoparasite of soil nematodes. This fungus produces motile, flagellated zoospores that swim through water films within soil pores. The zoospores are chemically attracted to nematodes, encysting on their cuticle, penetrating their body cavity, and consuming internal organs to complete their reproductive cycle.

132. (C) Meloidogyne spp.
Root-knot nematodes belonging to the genus Meloidogyne employ a highly specialized feeding strategy that involves modifying host cells. Upon entering the root, infective juveniles inject effector proteins that induce neighboring host cells to undergo repeated nuclear division without cell division. This process creates massive, multinucleate giant cells that act as specialized nutrient sinks.

133. (A) No single species completely dominates the community numerically
Species evenness is a critical component of biodiversity assessment that describes how equally individuals are distributed among different species in a community. High evenness ensures that the community is balanced and that no single opportunistic species completely dominates numerically. This structural balance is typical of stable, mature ecosystems with diverse ecological interactions and niches.

134. (D) The density at planting causing minimum detectable yield loss
The Damage Threshold in agricultural nematology is defined as the initial nematode density at planting that causes the first statistically or economically detectable loss in crop yield. This threshold is highly variable, depending on host crop tolerance, soil conditions, and nematode species, and serves as a primary baseline for economic management decisions.

135. (B) They have permeable cuticles, diverse trophic levels, and predictable responses
Soil nematodes are excellent bioindicators of soil health due to several unique biological characteristics. They possess highly permeable cuticles that expose them directly to chemical changes in the soil water. Furthermore, their diverse trophic levels and predictable responses to environmental disturbances allow researchers to assess the structural complexity and functional status of the broader soil ecosystem.

136. (C) Their inherently slow active movement capability
Active horizontal migration of plant-parasitic nematodes in agricultural fields is highly limited. Because these microscopic roundworms move via slow, undulatory propulsion through complex soil pores, they typically travel only a few meters per season. Consequently, the rapid horizontal spread of infestations across a field is almost always driven by passive agricultural or hydrological pathways.

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137. (D) A stable, mature ecosystem with complex food webs
A soil food web characterized by a high Structure Index and a low Enrichment Index represents a stable, mature ecosystem. This combination indicates that the soil is undisturbed, supporting a complex network of long-lived, sensitive omnivores and predators. The low Enrichment Index suggests that primary nutrient resources are cycled steadily without sudden, destabilizing bacterial blooms.

138. (A) The ETL is the population density at which action must be taken to prevent the population from reaching the EIL
The primary distinction between these two decision-making thresholds lies in their practical application. The Economic Threshold Level acts as an early warning action threshold. It represents the specific nematode density at which pest management measures must be initiated to prevent the growing population from reaching the higher Economic Injury Level, where real economic damage occurs.

139. (B) Cryobiosis
Cryobiosis is a specialized form of cryptobiosis activated in response to extreme cold and freezing temperatures. To survive, the nematode dramatically lowers its metabolic rate to

near-zero levels. It produces cryoprotectant molecules, such as glycerol, that prevent lethal ice crystal growth within its cells, protecting delicate cellular membranes until environmental temperatures rise.

140. (B) Some stylet-bearers may feed on fungi or roots, making assignment difficult
While morphological structures like stylets provide useful clues, relying solely on them to determine a nematode's exact diet is challenging. Many nematodes possess similar stylet structures but exhibit highly diverse feeding behaviors, targeting plant roots, fungal hyphae, or even acting as predators. This overlap makes accurate trophic classification based purely on morphology difficult.

141. (B) 1 to 5
The colonizer-persister scale is a standardized ecological framework that ranges from one to five. Nematodes are assigned values based on their life-history strategies, reproductive rates, and sensitivity to disturbance. Opportunistic, fast-reproducing species receive a value of one, while sensitive, long-lived persister species are assigned a value of five, reflecting ecosystem maturity.

142. (C) Crossing carrying capacity leading to resource depletion
A dense nematode population experiencing rapid growth will eventually cross its environment's carrying capacity. Once this threshold is exceeded, resource consumption outpaces replenishment, leading to severe food depletion and overcrowding. This resource exhaustion triggers high mortality rates and reduced reproduction, causing the population to suffer a sharp decline or crash.

143. (D) Detritivores / Microbivores
Soil nematodes that feed on decomposing organic matter and the colonizing microbial communities are classified as detritivores or microbivores. These organisms play a vital role in soil health by breaking down complex organic material and consuming bacteria and fungi. This activity accelerates the decomposition process, recycling essential nutrients and enhancing overall soil fertility.

144. (C) Monoculture practices and degraded soil health
A high proportion of plant-parasitic nematodes compared to free-living decomposers typically indicates degraded soil health, often caused by continuous monoculture practices. Growing a single susceptible crop repeatedly provides an abundant, specialized food source that fuels the parasitic population. Simultaneously, the lack of crop diversity simplifies the soil food web, reducing beneficial microbivores.

145. (A) P-2, Q-4, R-1, S-3
Soil food web indices provide valuable diagnostics. The Maturity Index reflects environmental disturbance and successional state, while the Enrichment Index indicates the availability of decomposable organic resources. The Channel Index measures the balance between fungal and bacterial decomposition pathways, and the Structure Index indicates food web complexity and the presence of high-trophic predators.

146. (D) The hardening of the body wall to form a protective cyst
Cyst nematodes within the genus Heterodera have evolved a highly effective survival strategy. As the adult female dies, her body wall undergoes a chemical tanning process that hardens and turns brown, forming a protective cyst. This durable structure encases the eggs, protecting them from desiccation, cold temperatures, and biological predators for many years.

147. (A) Logistic growth model
The logistic growth model is the most ecologically realistic representation of population dynamics in a limited environment. Unlike exponential models, the logistic model incorporates environmental resistance through a carrying capacity parameter. This variable ensures that population growth slows down as resources become limited, eventually stabilizing at a sustainable level supported by the environment.

148. (B) c-p 4 or 5
Predatory nematodes are typically classified as K-selected organisms, receiving high values of four or five on the colonizer-persister scale. These species possess large bodies, long lifespans, low reproductive rates, and extended generation times. Their high sensitivity to environmental disturbances, pollution, and physical soil

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stress makes them reliable indicators of stable ecosystems.

149. (A) Species richness and species evenness
The Shannon-Weaver Diversity Index is a widely used information-theoretic metric in community ecology. It is highly valued because it simultaneously accounts for both species richness, which is the total count of unique species, and species evenness, which is the relative abundance of those species. This combination provides a sensitive measure of community complexity.

150. (D) Antagonistic competitive exclusion
The scenario where Meloidogyne incognita prevents Rotylenchulus reniformis from colonizing roots due to its prior establishment is a clear example of antagonistic competitive exclusion. By establishing feeding sites first, Meloidogyne monopolizes root resources and alters host physiology, physically and nutritionally excluding the late-arriving species from occupying the same spatial niche.

151. (B) A period of chilling followed by warming
For many temperate nematode species, diapause is a genetically programmed survival state designed to endure winter. The primary environmental signal that terminates this dormancy is a prolonged period of chilling followed by gradual warming. This temperature sequence simulates the transition from winter to spring, ensuring that juveniles emerge when host crops are growing.

152. (C) Age-specific survival (l_x) and fecundity (m_x)
Calculating the net reproductive rate within a nematode life table requires integrating age-specific survival and fecundity data. By multiplying the proportion of individuals surviving to a specific age by the average number of female offspring produced at that age, ecologists can determine the overall growth potential of the population over a single generation.

153. (D) Disrupts spatial distribution and kills sensitive persisters
Deep plowing has a profound impact on soil ecology. This intensive mechanical practice physically disrupts the structured spatial distribution of nematode communities, exposing them to environmental stress and drying. Furthermore, the physical shear forces and rapid habitat changes selectively kill sensitive, long-lived persister nematodes, shifting community composition toward highly tolerant, opportunistic species.

154. (A) It is the primary independent variable determining yield loss
The initial nematode density at planting is a critical parameter in predictive nematology. It serves as the primary independent variable in damage models, such as the Seinhorst equation, directly determining the severity of root damage and subsequent crop yield loss. Accurately measuring this baseline density is essential for developing effective pest management strategies.

155. (B) Amino acids, sugars, and organic acids
Growing plant roots continuously exude a rich mixture of organic compounds into the rhizosphere, including amino acids, sugars, and organic acids. These biochemical compounds act as strong attractants for plant-parasitic nematodes. The nematodes detect these chemical gradients using their sensory amphids, guiding them directly toward the most susceptible zones of active root growth.

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156. (B) Paralongidorus
While most plant-parasitic nematodes are microscopic organisms less than two millimeters in length, species within the genus Paralongidorus represent a notable exception. These ectoparasites possess unusually long, thread-like bodies that can reach several millimeters in length, making them visible to the naked eye. They feed on root tips using extremely long stylets.

157. (A) High population density, food scarcity, and elevated temperature
In Caenorhabditis elegans, the formation of the specialized dauer juvenile stage is triggered by specific environmental stress signals. High population density, indicated by pheromone accumulation, combined with acute food scarcity and elevated temperatures, signals a harsh environment. In response, the nematode halts normal development to form a highly resistant, non-feeding dauer larva.

158. (C) Their body temperature fluctuates with the surroundings
Nematodes are poikilothermic organisms, meaning they lack internal mechanisms to regulate their body temperature. Consequently, their internal temperature fluctuates directly

177. (B) It functions as a muscular pump to ingest food and secrete enzymes
The esophageal bulb is a critical anatomical structure in the nematode digestive system. Equipped with powerful radial muscles, it functions as an efficient muscular pump that generates suction to ingest liquefied food. Additionally, this bulb helps regulate the secretion of cell-wall-degrading enzymes and effector proteins synthesized in the esophageal glands into host tissues.

178. (D) A combination of host, environment, and species
The Tolerance Limit in crop nematology is not a fixed biological constant. Instead, it is highly dynamic, depending on a complex interaction of host plant vigor, environmental conditions, and the specific nematode species. Soil fertility, moisture levels, and temperature can enhance or reduce the plant's capacity to tolerate parasite damage without experiencing yield loss.

179. (A) A resilient ecosystem with multiple active trophic levels
A highly diverse soil nematode community, indicated by a high Shannon-Weaver Index, signifies a healthy and resilient ecosystem. This diversity reflects the presence of multiple active trophic groups, including bacterivores, fungivores, omnivores, and predators. This complex food web structure enhances ecological stability, nutrient cycling efficiency, and natural suppression of plant-parasitic species.

180. (C) Control costs versus the financial value of saved yield
The critical distinction between the Economic Threshold Level and the Economic Injury Level is based on financial calculations. While the EIL represents the specific nematode density where the cost of crop damage equals the cost of treatment, the ETL is a lower action threshold designed to trigger control measures before damage costs reach that level.

181. (A) High bulk density
High soil bulk density is a physical property that indicates a highly compacted soil matrix with low total pore space. This compaction reduces the size and volume of the channels within the soil, physically restricting nematode locomotion, access to oxygen, and root colonization. Consequently, compacted soils support less abundant and diverse nematode populations.

182. (D) Galls provide a localized, nutrient-rich cellular sink
Root galls induced by nematodes like Meloidogyne are highly specialized physiological structures. By injecting effector proteins into host tissues, the nematodes induce cell division and hypertrophy, transforming normal root cells into multinucleate feeding sites. These galls function as metabolic sinks, continuously drawing sugars and nutrients from the plant to nourish the parasite.

183. (B) Development of more males as a stress response
High population densities of root-knot nematodes trigger intense intraspecific competition for limited nutrients within host roots. This starvation stress directly influences sex determination in juvenile stages. In response to nutritional deprivation, developing juveniles adapt by shifting their development toward becoming males, which are mobile, do not feed, and escape the overcrowded root tissue.

184. (C) Ideal, uncrowded conditions with unlimited resources
The intrinsic rate of natural increase is a theoretical demographic parameter defined under ideal, uncrowded environmental conditions. In the absence of density-dependent constraints, resource limitations, or predation, the population grows at its maximum potential speed. This rate is determined solely by the species' biological capacity for reproduction and survival under optimal conditions.

185. (A) P-3, Q-4, R-2, S-1
These parameters define critical ecological and economic thresholds in nematology. Carrying capacity represents the maximum sustainable population size. The Tolerance Limit is the density below which no damage occurs, while the Economic Injury Level is where control costs equal damage value. Minimum yield represents the residual crop output obtained at extremely high nematode densities.

186. (A) Active, migrating second-stage juveniles (J2) in soil pores
Active, migrating second-stage juveniles are highly vulnerable to chemical soil fumigants.

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sink that supplies the parasite with abundant nutrients.

168. (C) Bacterivorous nematodes
Bacterivorous nematodes play a vital role in soil fertility by driving nitrogen mineralization. Because bacteria possess a very low carbon-to-nitrogen ratio, they contain far more nitrogen than the nematodes require. When bacterivores consume bacteria, they excrete the excess nitrogen into the soil as ammonium, converting locked bacterial biomass into plant-available nutrients.

169. (D) Eggs hatch inside the body, and live juveniles emerge
The term ovoviviparous describes a reproductive strategy where embryonic development occurs entirely within eggs retained inside the female's uterus. Instead of laying eggs into the surrounding soil, the eggs hatch internally. The female then gives birth to active, live juveniles that emerge directly from her body, protecting the early developmental stages from environmental hazards.

170. (A) They possess an impermeable cuticle and excretory systems
Obligate endoparasites must withstand the high internal osmotic pressure of host plant cells. To survive, these nematodes possess a selectively permeable, multi-layered cuticle that regulates water movement. Additionally, they utilize highly efficient excretory and osmoregulatory systems to actively pump out excess solutes and water, maintaining their internal physiological balance within host tissues.

171. (B) Suspension of aerobic respiration and movement
Entering anoxybiosis in response to oxygen deprivation causes significant physiological changes. The nematode suspends aerobic respiration and active locomotion, entering a state of dormancy. This metabolic arrest conserves energy reserves, relying on anaerobic pathways to sustain basic survival. This adaptation allows the organism to survive prolonged flooding until oxygen levels recover.

172. (B) Low mortality until late in life
In demographic life table analysis, a Type I survivorship curve represents a population with unique mortality patterns. It indicates that individuals experience low mortality rates throughout their early and middle developmental stages, with most deaths occurring late in life due to aging. This pattern is typical of species that invest significant energy in offspring protection.

173. (A) The base of the natural logarithm
In the mathematical framework of the Seinhorst damage model, the constant z is defined using the exponential base e. This variable represents the base of the natural logarithm, which is approximately equal to 2.718. It is used to model the continuous, exponential decline of crop yield as nematode density increases beyond the tolerance threshold.

174. (C) Localized host root growth and limited active movement
The highly aggregated, patchy horizontal distribution of nematodes in undisturbed soils is driven by localized ecological factors. Because nematodes move slowly through soil pores, their populations remain concentrated near host root systems. This limited active locomotion, combined with the clumped growth patterns of host plants, maintains distinct high-density patches separated by uninhabited zones.

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175. (D) They respond explosively to pulses of organic matter
Nematodes assigned a value of one on the colonizer-persister scale are termed enrichment opportunists due to their rapid reproductive capacity. When organic amendments or fertilizers are added to soil, they trigger rapid bacterial blooms. These opportunistic microbivores respond explosively, multiplying quickly to exploit this abundant food supply before populations stabilize.

176. (C) Pasteuria penetrans
Pasteuria penetrans is a premier biological control agent that acts as an obligate parasite of female root-knot nematodes and their eggs. The bacterial endospores attach to migrating juveniles and germinate inside their bodies. The vegetative growth eventually consumes the female's internal organs, sterilizing her and replacing her eggs with millions of new bacterial endospores.

with the surrounding soil environment. This reliance on ambient temperature strongly governs their metabolic rates, locomotion speeds, developmental durations, and reproductive outputs, making them highly sensitive to seasonal and climatic thermal changes.

159. (A) A value between 0 and 1 (or 0% to 100%)
In the Seinhorst damage model, relative crop yield is expressed as a normalized value ranging from zero to one. This ratio compares the yield obtained at a specific nematode density to the maximum yield achieved under nematode-free conditions. This proportional scale allows researchers to standardize and compare damage across different crop varieties and soil types.

160. (C) It correlates with crop health and parasite burden
The Plant Parasitic Index is a valuable agricultural metric because it focuses exclusively on the parasitic component of the soil nematode community. Changes in this index correlate directly with the abundance of root-feeding species and the severity of the parasite burden. This relationship helps growers assess crop health risks and monitor the effectiveness of management strategies.

161. (B) It ensures moisture films while allowing oxygen diffusion
Field capacity represents the optimal soil moisture state for terrestrial nematodes. At this level, excess gravitational water has drained from large pores, allowing rapid oxygen diffusion to sustain aerobic respiration. Simultaneously, small pores retain thin water films that coat soil particles, providing the physical leverage and surface tension necessary for efficient undulatory nematode locomotion.

162. (D) They stimulate microbivorous nematodes, increasing the EI
Adding organic amendments to soil introduces complex carbon sources that stimulate rapid bacterial and fungal growth. This microbial bloom provides an abundant food supply for bacterivorous and fungivorous nematodes, fueling their rapid reproduction. Consequently, the relative abundance of these opportunistic microbivores rises, driving the Enrichment Index upward and accelerating overall soil nutrient cycling.

163. (A) Sandy soils provide larger pores and aeration for movement
Sandy soils typically experience more severe crop damage from Meloidogyne species compared to heavy clay soils. The coarse texture of sand creates large, well-aerated pore spaces that physically accommodate the active movement of nematode juveniles. This open structure, combined with optimal oxygen levels, facilitates rapid root location, penetration, and infection by the parasites.

164. (C) Variance-to-mean ratio
The variance-to-mean ratio is a widely used statistical metric in spatial ecology to evaluate how individuals are distributed. A ratio equal to one indicates a random distribution, while a ratio less than one suggests a uniform pattern. A ratio significantly greater than one mathematically describes a highly aggregated, clumped, or patchy spatial distribution.

165. (A) Both A and R are true and R is the correct explanation of A.
Human-mediated transport of soil and plant material is a primary pathway for spreading quarantine nematodes globally. Because these microscopic roundworms move slowly through their own active locomotion, they lack physical adaptations for rapid, long-distance terrestrial migration. Consequently, their spread between distant geographic regions relies almost entirely on passive, anthropogenic movement.

166. (D) One or a few highly abundant species
A nematode community with extremely low species evenness is highly imbalanced and heavily dominated by one or a few highly abundant species. This structure is typical of degraded or highly disturbed soil environments where a single opportunistic species outcompetes others. In these systems, the rare or sensitive species are suppressed, resulting in low overall diversity.

167. (B) Cell wall dissolution and protoplast fusion of adjacent cells
The syncytium induced by cyst nematodes is a highly specialized multinucleate feeding structure. It differs from the giant cells of root-knot nematodes because it is formed through cell wall dissolution and the subsequent fusion of protoplasts of adjacent host root cells. This process creates a massive, continuous metabolic

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Because they move freely through water films within soil pores, their highly permeable cuticles are directly exposed to dissolved toxic vapors. In contrast, eggs encased in cysts, dormant anhydrobiotic larvae, or adults embedded deep in roots are shielded from chemical contact.

187. (B) Releasing toxic allelochemicals into the rhizosphere
Marigolds suppress soil nematode populations primarily through chemical antagonism. Their roots continuously synthesize and release powerful biochemical compounds, such as alpha-terthienyl, into the rhizosphere. These allelochemicals act as natural nematicides, penetrating the nematode cuticle and causing oxidative damage that disrupts cellular functions, effectively reducing pest densities in the soil.

188. (B) It is a selectively permeable, multi-layered collagenous matrix
The nematode cuticle is a highly specialized, non-cellular structure composed of a selectively permeable, multi-layered collagenous matrix. This biochemical composition provides structural flexibility and strength, allowing the nematode to maintain high hydrostatic pressure. Furthermore, its selective permeability regulates water and solute transport, helping the organism survive fluctuating osmotic pressures in the soil.

189. (A) Decomposition is dominated by fungal pathways
In soil food web analysis, a high Channel Index indicates that organic matter decomposition is dominated by fungal pathways. Fungi decompose complex, lignin-rich organic materials slowly, supporting a distinct community of fungivorous nematodes. This pathway contrasts with bacterial decomposition channels, which cycle nutrients rapidly and dominate in heavily fertilized, highly disturbed soils.

190. (C) High genetic variation for adaptation to resistance
While parthenogenesis offers several reproductive advantages, such as rapid population growth and the ability of a single individual to colonize a new habitat, it lacks the genetic benefits of sexual reproduction. Because offspring are clones of the parent, parthenogenetic populations exhibit very low genetic variation, limiting their capacity to adapt to new plant resistance genes.

191. (D) Natality, mortality, immigration, and emigration
Nematode population dynamics are fundamentally driven by demographic parameters that govern abundance. The balance between birth rates, death rates, and physical movement into or out of a specific area determines whether a population expands, declines, or remains stable. These factors integrate environmental resources, predation, and climate to shape overall soil community structures.

192. (C) Aggregated (Clumped)
A spatial distribution where the variance is significantly greater than the mean indicates a highly aggregated or clumped pattern. This patchy distribution is typical of agricultural nematode populations, where high-density hot spots are separated by large areas of low abundance. This clumped structure is driven by localized host root availability and slow active movement.

193. (B) Securing a protected food sink while minimizing movement energy
The evolution of sedentary endoparasitism represents a highly successful ecological adaptation. By entering host roots and establishing permanent feeding sites, these nematodes secure a continuous, protected supply of nutrients. This stationary lifestyle eliminates the energetic costs of active locomotion and host-seeking in the soil, allowing the parasite to maximize reproductive output.

194. (D) The proportion of individuals belonging to species i
In the mathematical calculation of the Shannon-Weaver Diversity Index, the variable p_i represents the proportion of individuals belonging to species i. It is calculated by dividing the abundance of a single species by the total number of individuals in the sample, reflecting relative abundance and species dominance within the community.

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195. (A) Meloidogyne incognita facilitating Fusarium oxysporum infection
The interaction between Meloidogyne incognita and Fusarium oxysporum is a classic disease complex. During feeding, the nematode damages root tissues and alters host physiology, creating entry wounds and weakening plant defenses. This parasitic activity facilitates colonization by the fungal pathogen, resulting in significantly

121. (D) Combined damage greater than the sum of individual damage
In plant pathology, synergism describes a disease complex where the co-occurrence of two pathogens causes enhanced crop damage. When plant-parasitic nematodes and pathogenic fungi infect a host simultaneously, the nematode's feeding activity wounds the roots, facilitating fungal entry. This combined attack results in significantly more severe disease symptoms than the sum of their individual damages.

122. (A) Regulating the thickness of water films for optimal leverage
Soil moisture directly governs nematode locomotion by determining the physical thickness of water films surrounding soil particles. If the soil is too dry, water films disappear, causing osmotic stress and halting movement. In saturated soils, the lack of surface tension limits leverage. Optimal movement occurs at field capacity, where water films provide perfect physical leverage.

123. (B) Geographical latitude defined by political borders
The ecological niche of a plant-parasitic nematode is defined by biological and environmental parameters, including its host range, tissue preferences, and optimal temperature and moisture requirements. Political boundaries, such as state or country lines, are human constructs that have no influence on the biological interactions or environmental tolerances that define a species' true ecological niche.

124. (B) Maturity Index
The Maturity Index is a highly effective ecological metric used to assess the successional status and long-term stability of a soil nematode community. By weighting taxa based on their colonizer-persister values, this index reflects how the community responds to environmental disturbances. A high index indicates a stable, mature ecosystem dominated by sensitive, long-lived persister species.

125. (A) Both A and R are true and R is the correct explanation of A.
Migratory endoparasites like Pratylenchus cause severe root damage because they retain complete mobility inside the host. As they move through the root cortex, they use their stylet and secrete cell-wall-degrading enzymes to destroy plant cells. This continuous migration and feeding collapses cell walls, leading to extensive necrotic lesions that severely impair root function.

126. (C) Density-dependent factors approaching carrying capacity
An exponentially growing nematode population cannot sustain rapid growth indefinitely in a finite environment. As population density increases, resource limitations and crowding trigger negative density-dependent factors. The exhaustion of host root tissue or microbial prey reduces reproduction and increases mortality, causing the growth rate to slow and stabilize near the environment's carrying capacity.

127. (D) High juvenile proportions indicate high growth potential
Assessing the age distribution of a soil nematode population is critical for predicting future growth trends. A population containing a high proportion of young juvenile stages indicates active reproduction and high growth potential. In contrast, a community dominated by adults suggests a mature or declining population with limited future growth, helping ecologists model population dynamics.

128. (C) Root exudates that stimulate dormant eggs to hatch
Hatching factors are specialized chemical signals released by host plant roots into the rhizosphere. For cyst nematodes, these chemicals act as specific physiological triggers that stimulate dormant eggs encased inside cysts. Upon detecting these compounds, the juveniles within the eggs resume metabolic activity and hatch, ensuring they emerge only when suitable hosts are actively growing.

129. (B) Minimized, allowing for multiple generations
Because nematodes are poikilothermic, their metabolic rates are directly governed by external temperatures. Under optimal thermal conditions, enzymatic reactions and physiological processes occur at peak efficiency. This optimization minimizes the duration of each developmental stage, allowing the nematode to rapidly complete its life cycle and produce multiple generations within a single crop growing season.

130. (D) $D = \Sigma(p_i^2)$
Simpson's Diversity Index is mathematically calculated by summing the squared proportions of

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205. (A) The population growth rate approaches zero
In the mathematical formula for logistic population growth, as the population size N approaches the environmental carrying capacity K, the resource term approaches zero. This reduction slows the overall growth speed, causing the population curve to flatten and stabilize. This mathematical behavior represents the balancing effect of environmental resistance on population expansion.

206. (C) Enrichment Index
The Enrichment Index is a highly effective diagnostic tool used to evaluate the nutritional status of the soil food web. It measures the relative abundance of opportunistic, fast-reproducing bacterivorous and fungivorous nematodes. A high index indicates a rapid influx of primary organic resources, which drives microbial activity and subsequent nutrient cycling.

207. (D) Stunted, stubby root systems with no fine root development
Ectoparasitic nematodes like Belonolaimus feed on root tips and meristematic tissues from the outside. Their destructive feeding halts root elongation and prevents the development of fine feeder roots. This feeding behavior results in highly stunted, stubby, and swollen root systems that are inefficient at absorbing water and essential nutrients from the soil.

208. (C) More sensitive to changes in the dominant species
Simpson's Diversity Index differs from the Shannon-Weaver Index because it squares the relative abundance of each species. This squaring process places greater mathematical weight on common species, making Simpson's Index highly sensitive to changes in the dominant taxa. In contrast, the Shannon-Weaver Index is more sensitive to rare species within the community.

209. (B) Hydrostatic pressure against a cuticle acting on soil surface tension
Nematode locomotion relies on the physical principles of hydrodynamics and biomechanics. Alternating contractions of longitudinal muscles generate sinusoidal waves along the body. These movements act against high internal hydrostatic pressure within the tough cuticle. This pressure, combined with surface tension in thin soil water films, provides the leverage needed for forward propulsion.

210. (D) Large dorylaimid persisters
Large dorylaimid persister nematodes are highly sensitive to physical soil disturbances due to their K-selected life history traits. They possess long lifespans, low reproductive rates, and rely on structured soil pores. Mechanical tillage physically damages their large bodies and disrupts their habitat, making them reliable indicators of physical soil disturbance and degradation.

211. (A) Ensure juveniles emerge in the presence of growing host roots
Relying on specific host root exudates as hatching factors is an evolutionary adaptation for cyst nematodes. This dependence ensures that dormant infective juveniles hatch and emerge into the soil only when actively growing host roots are nearby. This precise timing prevents starvation and maximizes their chances of quickly locating a suitable food source.

212. (C) It paralyzes them, halting locomotion and root penetration
Because nematodes are poikilothermic, their physiological activity is governed by temperature. A sudden drop in soil temperature below their thermal minimum slows down metabolic processes and enzyme activity. This drop paralyzes active root-knot nematode juveniles, halting their undulatory locomotion and preventing them from navigating soil pores and penetrating host root tissues.

213. (A) All species in the sample have the exact same number of individuals
Species evenness measures how equally distributed individuals are among the different species in a community. This parameter reaches its maximum theoretical value when every single species present in the sample contains the exact same number of individuals. This balanced structure represents a highly stable community with no dominant opportunistic species.

214. (D) They require specific soil environments easily disrupted by farming
Utilizing predatory nematodes as broad-scale biological control agents is limited by their environmental sensitivity. These K-selected organisms require stable, undisturbed soil matrices with adequate moisture and pore space to survive. Standard agricultural practices, such as mechanical tillage, chemical fertilization,

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and fumigation, easily disrupt these conditions, rapidly decimating predator populations.

215. (B) Resource partitioning
Resource partitioning is an evolutionary adaptation that allows co-occurring plant-parasitic nematode species to minimize direct competition on a single host. By adapting to feed on separate root zones, tissue depths, or utilizing different metabolic sinks, the competing species divide available resources, allowing both populations to coexist without causing competitive exclusion.

216. (C) Soil systems rich in complex, slowly decomposing organic matter
A high abundance of fungivorous nematodes typically indicates soil systems rich in complex, slowly decomposing organic matter, such as forest soils or cover-cropped fields. These organic materials, containing cellulose and lignin, favor fungal decomposition over bacterial pathways. This active fungal biomass provides an abundant food resource that supports large fungivorous nematode populations.

217. (D) r-strategists
Nematodes characterized by short life cycles, high reproductive capacities, and high tolerance to environmental stress are classic r-strategists. On the colonizer-persister scale, these organisms receive low values of one or two. They are adapted to rapidly colonize disturbed habitats and exploit sudden nutrient pulses, multiplying quickly before populations stabilize.

218. (B) The active movement of nematodes through a filter
The Baermann funnel technique is a standard laboratory method for extracting nematodes from soil or plant tissue. This process relies on the active movement of live nematodes. When the sample is suspended in water on a filter, active nematodes swim through the filter pores and settle at the bottom of the funnel, separating them from debris.

219. (B) It acts as a keystone species connecting multiple trophic levels
Omnivorous dorylaimid nematodes play a critical role in soil food webs by connecting multiple trophic levels. Their diverse diet, which includes bacteria, fungi, algae, and small invertebrates, allows them to influence several biological pathways. This trophic flexibility makes them vital for nutrient cycling and stabilizing food web structures in mature ecosystems.

220. (B) Omnivores and predatory nematodes (c-p 3 to 5)
The Structure Index is an environmental diagnostic calculated using the relative abundance of long-lived, high-c-p omnivores and predatory nematodes. These organisms are highly sensitive to environmental disturbances and physical stress. A high index indicates a mature, stable soil food web that has recovered from disturbance, supporting complex biological interactions and multiple trophic levels.

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221. (A) Anhydrobiosis of juveniles within seed galls
Nematodes within the genus Anguina, particularly Anguina tritici, utilize anhydrobiosis as a primary survival mechanism. The infective juveniles enter the developing wheat flower, transforming the grains into protective seed galls. Within these dry galls, the juveniles enter deep anhydrobiosis, remaining viable and dormant for many years until moisture triggers their reactivation and emergence.

222. (C) Evaluating soil health by assessing entire nematode communities
Nematode faunal analysis is an ecological diagnostic method used to evaluate soil health and food web structure. Instead of counting individual pest species, this analysis assesses the entire soil nematode community across all trophic levels. By analyzing their abundance, diversity, and colonizer-persister values, researchers can determine the nutrient status and disturbance levels.

223. (D) It serves as a gradient cue for locating respiring host roots
Carbon dioxide is a vital chemical signal in the soil rhizosphere. Growing plant roots continuously respire, releasing carbon dioxide and establishing a concentration gradient in the soil water. Plant-parasitic nematodes detect this gradient using their sensory amphids, guiding their chemotactic movement directly toward active root zones to locate suitable hosts.

224. (C) Density
In population ecology, the term density refers to the number of individuals of a single species or taxon found within a standardized unit of

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soil volume or weight. Measuring nematode density is essential for assessing crop damage risks, tracking population changes over time, and evaluating the effectiveness of agricultural management practices.

225. (B) An undisturbed natural ecosystem
A soil profile exhibiting high species richness, high evenness, a high Maturity Index, and a low Plant Parasitic Index represents an undisturbed natural ecosystem. This structure indicates a mature, stable community dominated by sensitive, high-c-p free-living species. The low parasitic index suggests that natural biological suppression keeps plant-parasitic populations at harmless levels.

226. (D) A strong, multilayered cuticle acting against hydrostatic pressure
Nematodes maintain high internal turgor pressure to support their body structure and facilitate locomotion. To prevent bursting under this intense hydrostatic pressure, they possess a strong, multilayered cuticle. This collagenous extracellular structure provides high tensile strength, acting as a flexible exoskeleton that resists internal pressure while allowing undulatory body movements.

227. (A) A slow, controlled rate of rehydration to prevent membrane rupture
For an anhydrobiotic nematode to successfully survive reactivation, the rehydration process must be slow and controlled. Rapid water uptake can cause extreme osmotic shock, swelling cells too quickly and rupturing delicate membranes before they can reorganize. A gradual rehydration allows cellular components and protective sugars to slowly rehydrate, restoring normal metabolic functions safely.

228. (C) Depletion of oxygen and accumulation of toxic byproducts
Saturated and flooded soils suffer from poor gas exchange, leading to rapid oxygen depletion and anaerobic conditions. Because most terrestrial plant-parasitic nematodes are obligate aerobes, they cannot sustain their metabolism without oxygen. Prolonged flooding deprives them of oxygen while allowing toxic anaerobic byproducts to accumulate, causing high mortality over time.

229. (A) Longidoridae and Xiphinematidae
Nematodes belonging to the families Longidoridae and Xiphinematidae, particularly the genera Longidorus and Xiphinema, are notorious vectors of plant nepoviruses. During their ectoparasitic feeding on root cells, these large nematodes ingest viral particles. The virus adsorbs to their esophageal lining and is subsequently transmitted to healthy host plants during subsequent feeding events.

230. (D) An exponential decline curve up to a minimum yield (m)
The Seinhorst model mathematically describes the relationship between initial nematode density and relative crop yield. This relationship is modeled as an exponential decline curve that starts once the tolerance limit is exceeded. The yield continues to drop exponentially with increasing nematode density until it flattens out at a constant minimum yield.

231. (B) Clustered inoculum, limited movement, and repeated cultivation
The characteristic development of localized "hot spots" of nematode infestation in fields is driven by multiple factors. Because nematodes are microscopic and move slowly through soil pores, their active dispersal is limited. This slow movement, combined with clustered initial inoculum and repeated tillage that spreads pests along rows, maintains highly aggregated populations.

232. (C) The maximum amount of water a soil holds against gravity
Field capacity is defined as the maximum volume of water that a specific soil can retain against the downward pull of gravity after excess water has drained. This soil moisture state is highly stable, providing an ideal balance of water-filled micro-pores for nematode locomotion and air-filled macro-pores for essential oxygen diffusion.

233. (D) Cost of control measures per unit area
In the mathematical equation used to calculate the Economic Injury Level, the variable C represents the total cost of implementing pest control measures per unit area. This value is critical for determining the density threshold where the financial loss caused by nematode damage equals the financial cost of applying treatment.

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253. (A) Fungivorous stylets are small, delicate, and lack basal knobs
Morphological differences in stylet structure reflect different feeding adaptations. Fungivorous nematodes possess small, delicate stylets that typically lack prominent basal knobs, as they only need to pierce thin fungal hyphae. In contrast, plant-parasitic species possess larger, robust stylets with distinct basal knobs that provide attachment points for powerful muscles to pierce tough plant cell walls.

254. (C) 1.0 (or 100%)
In the mathematical framework of the Seinhorst damage model, when the initial nematode density is exactly equal to the Tolerance Limit, the relative crop yield is 1.0. This value indicates that the crop has suffered zero detectable damage or yield loss, as the plant's natural compensatory growth mechanisms are fully capable of offsetting the parasite activity.

255. (D) Reducing pore space and restricting movement of larger species
High soil compaction directly degrades the physical habitat of soil nematodes. By compressing soil particles, compaction significantly reduces total pore space and narrows the channels within the soil matrix. This structural change physically restricts the locomotion of larger nematode species, trapping them, limiting their access to oxygen, and reducing their overall abundance.

256. (C) It quantifies the population equality of different species
Species evenness is a critical component of biodiversity assessment. Its fundamental role is to quantify the equality of population sizes among the different species present in a community. High evenness indicates that individuals are distributed relatively equally, whereas low evenness reflects a community dominated by a few highly abundant, opportunistic species, signaling disturbance.

257. (B) Global transport of infected seed potatoes and nursery stock
The international transport of infected seed potatoes, seedlings, and bare-root nursery stock is a classic anthropogenic mechanism for passive nematode dispersal. Because nematodes are microscopic and move slowly on their own, human-mediated movement bypasses natural geographical barriers, introducing devastating agricultural pests into previously uninfested fields and regions across continents.

258. (D) Accumulating solutes to balance external osmotic pressure
Surviving high osmotic stress through osmobiosis requires specialized physiological adjustments. To prevent lethal water loss in hypertonic soil solutions, nematodes alter their membrane permeability and actively accumulate internal solutes. This accumulation increases their internal osmotic potential, balancing the high external osmotic pressure and maintaining cellular hydration and integrity.

259. (B) Total abundance drops, followed by a bloom of c-p 1 opportunists
Applying a broad-spectrum chemical fumigant causes a catastrophic drop in the total abundance of all soil nematodes. However, once the chemical dissipates, the sterilized soil contains abundant dead organic matter and dead microbes. This resource-rich environment triggers a rapid bloom of opportunistic, c-p one bacterivorous nematodes, which multiply quickly to dominate the early successional stage.

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260. (C) It leads to anaerobic conditions that are lethal over time
Long-term flooding of agricultural soils severely restricts gas exchange, leading to rapid oxygen depletion. Because most terrestrial plant-parasitic nematodes are obligate aerobes that require oxygen for metabolism, prolonged exposure to these anaerobic conditions is lethal. The physical lack of oxygen, combined with toxic anaerobic byproducts, causes significant population declines over time.

261. (A) Determine age-specific survival, fecundity, and predict growth
In population ecology, demographic life tables are vital analytical tools. They compile age-specific data on survival and fecundity within a cohort, allowing researchers to track mortality patterns and calculate reproductive potential. These biological parameters help ecologists predict future population growth, model outbreak risks, and evaluate how environmental factors influence nematode population dynamics.

channels that facilitate fungal colonization. This combined attack results in significantly earlier, more severe, and destructive wilt symptoms.

244. (C) Outside the root in a gelatinous matrix within the soil
Semi-endoparasitic nematodes like Rotylenchulus reniformis exhibit a unique feeding and reproductive strategy. The female penetrates the host root only partially, leaving her posterior body exposed to the soil. Consequently, her eggs are deposited outside the root tissue, encased within a protective gelatinous matrix secreted directly into the surrounding soil matrix.

245. (A) Long life span and slow population growth
K-selected nematode species possess adaptations suited for stable, highly competitive environments. These organisms typically exhibit long lifespans, low reproductive rates, and slow population growth. They invest significant metabolic energy in individual survival and offspring viability rather than rapid multiplication, making them highly sensitive to environmental disturbances and physical soil stress.

246. (A) Fungal pathways and higher trophic levels begin to dominate
Moving from a highly enriched soil state to a stable, basal state represents an ecological successional shift. As easily decomposable organic resources are depleted, bacterial populations decline. Consequently, fungal decomposition pathways and higher trophic levels, including omnivores and predators, begin to dominate the soil food web, restoring structural complexity and nutrient stability.

247. (B) Differences in host plant tolerance and susceptibility to damage
The Damage Threshold is highly variable across agricultural crops, primarily due to differences in host plant genetics. Some plant species or cultivars possess high tolerance and vigor, allowing them to withstand significant root parasitism without experiencing yield loss. In contrast, susceptible varieties suffer severe damage at low nematode densities, altering the threshold.

248. (C) Soil water potential determining moisture film thickness
From an ecological perspective, the most relevant measure of soil moisture for nematodes is soil water potential. This parameter determines the physical thickness of the water films coating soil particles. Because nematodes are aquatic organisms that require these films for leverage and gas exchange, water potential directly dictates their locomotion, respiration, and survival.

249. (D) Phasmids and amphids
Nematodes possess highly specialized sensory structures that are vital for detecting environmental cues. Amphids, located on the anterior region, function as primary chemoreceptors that allow nematodes to perceive chemical gradients of root exudates, guiding their chemotactic movement. Phasmids, situated in the posterior region, serve similar chemosensory functions, assisting in host finding and orientation.

250. (A) Constant and unlimited resources
The mathematical model for exponential population growth describes population expansion under theoretical, non-limiting conditions. This model assumes that resources, such as food and space, are constant and unlimited, and that environmental resistance is completely absent. Consequently, the per capita growth rate remains constant, causing the population to multiply rapidly without bound over time.

251. (B) Glycolysis and fermentation pathways
When facing anaerobic conditions during anoxybiosis, nematodes must adapt their metabolism to survive. Lacking oxygen to sustain aerobic respiration, they halt active movement and switch to anaerobic energy pathways. The organism relies on glycolysis and specialized fermentation pathways to generate the basic ATP required to maintain cellular integrity until oxygen returns.

252. (B) Radopholus
Nematodes belonging to the genus Radopholus, particularly Radopholus similis, are the primary causal agents of “spreading decline” in citrus crops. These migratory endoparasites feed destructively within the root cortical tissue, causing extensive cellular necrosis and root decay. This damage impairs water uptake, leading to progressive tree decline that spreads through citrus orchards.

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locomotion. Under these arid conditions, the thin water films coating soil particles disappear. Without these liquid films, nematodes lose the hydrostatic leverage and surface tension required for their undulatory sinusoidal movement, trapping them and halting active migration.

272. (B) They are sensitive to disturbance and have long generation times
K-selected nematodes receive high values of four or five on the colonizer-persister scale due to their life history traits. These organisms possess large body sizes, long lifespans, low reproductive rates, and extended generation times. Because they are exceptionally sensitive to environmental stress, pollution, and physical soil disturbances, they serve as indicators of ecosystem stability.

273. (B) Maximizing infection success by emerging when host is present
A synchronized hatching strategy triggered by host root exudates provides a major evolutionary advantage. This adaptation ensures that dormant eggs hatch only when actively growing host roots are present in the rhizosphere. This precise timing maximizes infection success by placing active juveniles in direct proximity to a food source, preventing starvation in empty soil.

274. (D) It derives nutrition from multiple diverse trophic levels
Strictly omnivorous nematodes are characterized by their feeding flexibility. Unlike specialized microbivores or parasites, omnivores possess complex mouthparts that allow them to derive nutrition from multiple diverse trophic levels. Their diet includes bacteria, fungi, algae, protists, and small soil invertebrates, allowing them to adapt to changing food resources in stable ecosystems.

275. (A) Nematodes migrate toward their species-specific thermal optimum
Thermotaxis is the biological process where nematodes orient their movement along temperature gradients. Because they are poikilothermic, their physiological efficiency depends on ambient warmth. When exposed to a thermal gradient, nematodes detect temperature differences and migrate toward their species-specific thermal optimum, where metabolic processes and reproductive rates are maximized.

276. (C) Average female offspring produced by a female in her lifetime
In demographic life table analysis, the net reproductive rate represents the average number of female offspring produced by a female over her entire lifetime. Calculated by integrating age-specific survival and fecundity, this parameter indicates whether a population is expanding, declining, or remaining stable under specific environmental conditions.

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277. (A) Migratory ectoparasite
Nematodes within the genus Xiphinema occupy the ecological niche of migratory ectoparasites. These large, mobile organisms remain outside the plant roots throughout their life cycle. They feed by inserting their extremely long stylets deep into root cells, sucking out liquefied contents, and then moving to new root tips, causing cell necrosis and transmitting viruses.

278. (D) Cryobiosis
Cryobiosis is a specialized form of cryptobiosis that allows nematodes to survive extreme freezing temperatures. In response to cold, the nematode synthesizes cryoprotectant molecules that prevent lethal ice crystal formation within its cells, protecting delicate membranes. This physiological arrest allows them to remain dormant in frozen soils until spring warmth safely revives them.

279. (B) Monetary yield loss equals the cost of control measures
The Economic Injury Level is a critical financial threshold in integrated pest management. It represents the specific nematode population density at which the monetary value of crop yield lost to damage equals the financial cost of implementing control measures. Maintaining populations below this level ensures that pest management remains economically beneficial.

280. (C) High abundance of large, slow-reproducing omnivores and predators
A high Structure Index in soil faunal analysis indicates a highly structured, mature soil food web. This index reflects a high relative abundance of long-lived, sensitive, and slow-reproducing omnivores and predatory nematodes. Because these species are highly sensitive to stress, their abundance confirms that the soil ecosystem is stable and undisturbed.

262. (D) Mitotic parthenogenesis allowing rapid multiplication
Under favorable environmental conditions, Meloidogyne incognita utilizes mitotic parthenogenesis as its primary reproductive strategy. This asexual mechanism allows females to produce viable, identical offspring without requiring fertilization by males. By bypassing the need to locate mates, this strategy enables rapid population expansion, allowing the parasite to quickly exploit susceptible host crops.

263. (B) Whether decomposition is driven by bacteria or fungi
The Channel Index is a valuable diagnostic tool used in soil faunal analysis. It measures the relative abundance of fungivorous and bacterivorous nematodes, indicating whether organic matter decomposition is driven primarily by bacterial or fungal pathways. This assessment reveals the speed of nutrient cycling and the structural complexity of the soil food web.

264. (C) It causes an exponential rise in specific nematode populations
Continuous monoculture of a susceptible host crop has a profound impact on soil communities. By repeatedly providing an abundant, specialized food resource, monoculture removes nutritional constraints for crop-specific parasites. This continuous availability triggers an exponential rise in their populations, leading to severe root damage, while reducing overall food web complexity and biodiversity.

265. (D) Residual yield at the maximum possible nematode density
In the Seinhorst damage model, the parameter m represents the minimum relative yield. This variable defines the residual crop yield obtained even under extremely high initial nematode densities, where further increases in parasite numbers cause no additional damage. It reflects the plant's capacity to produce a basic minimum yield despite severe root damage.

266. (A) A heavily sclerotized, barrel-shaped stoma with large teeth
Predatory nematodes within the order Mononchida are morphologically adapted for carnivory. They are characterized by a heavily sclerotized, spacious, and barrel-shaped stoma armed with prominent teeth or cutting plates. These robust structures are used to seize, puncture, and consume other soil nematodes and microinvertebrates, distinguishing them from delicate microbivores.

267. (B) Dispersing bacterial cells to new soil microhabitats
In addition to regulating bacterial populations through direct consumption, microbivorous nematodes influence microbial ecology by acting as vectors. As they migrate through soil water films, bacterial cells adhere to their cuticles or survive passage through their digestive tracts. This active movement disperses bacteria to new, nutrient-rich soil microhabitats, enhancing microbial colonization and decomposition.

268. (B) The temperature where critical proteins and enzymes denature
The upper lethal temperature limit for a nematode species is determined by biochemical constraints. As environmental temperatures rise beyond physiological thresholds, thermal energy disrupts molecular bonds, causing critical cellular proteins and enzymes to denature. This denaturation halts metabolic pathways, damages cell membranes, and leads to rapid, irreversible physiological failure and death.

269. (A) A highly disturbed community dominated by a single species
A Shannon-Weaver Diversity Index value close to zero indicates extremely low diversity within the community. This low value typically represents a highly disturbed or degraded soil environment where a single opportunistic species outcompetes others. In these systems, the lack of species richness and evenness reflects a simplified, unstable soil food web.

270. (C) Arthrobotrys dactyloides
Arthrobotrys dactyloides is a highly specialized, nematophagous fungus that acts as a natural enemy of soil nematodes. This fungus produces specialized, three-celled constricting rings along its hyphae. When a nematode crawls through a ring, the cells rapidly expand in response to physical friction, trapping the nematode, penetrating its cuticle, and digesting its internal tissues.

271. (D) Thin water films fail to provide leverage for propulsion
In extremely dry soils below the permanent wilting point, the lack of water restricts nematode

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234. (A) Alteration of host root growth and food availability
Soil temperature influences nematode biology through both direct and indirect pathways. An indirect effect is the alteration of host root growth and physiological activity. Temperature changes shape the development and vigor of host plants, which directly dictates the availability of root tissue and nutrients that parasitic nematodes require to feed, develop, and reproduce.

235. (B) Ignores relative abundance of each species
Species richness is a simple count of the total number of unique species identified within a sample. A major limitation of relying solely on this index is that it completely ignores the relative abundance of each species. Consequently, a community dominated by a single species can have the same richness as a balanced ecosystem.

236. (B) Being a genetically programmed arrest requiring specific cues
Diapause is distinguished from simple environmental quiescence by its physiological and genetic basis. While quiescence is an immediate metabolic response to temporary stress, diapause is a genetically programmed developmental arrest. It is triggered by seasonal environmental cues to ensure survival and must be terminated by specific physiological sequences, such as chilling.

237. (A) Summing the proportion of each taxon multiplied by its c-p value
The Maturity Index is calculated using a weighted mathematical formula. This process involves identifying the relative proportion of each nematode taxon within the sample, multiplying that value by the taxon's assigned colonizer-persister score, and summing these products. The resulting index provides a quantitative measure of environmental disturbance and successional maturity.

238. (C) Opportunistic bacterivores (c-p 1), such as Rhabditidae
Sterilizing soil eliminates the active biological community, leaving behind dead organic matter. When colonizers re-enter, opportunistic bacterivorous nematodes, such as Rhabditidae, are the first to multiply. Possessing low colonizer-persister values, short lifespans, and high reproductive rates, these microbivores respond explosively to the subsequent bacterial blooms, dominating the initial successional stage.

239. (D) Global trade of contaminated seed and agricultural machinery
Global trade is historically the most significant abiotic pathway for the inter-continental spread of cyst nematodes. Because these microscopic pests form highly durable, soil-dwelling cysts that survive desiccation, they are easily transported across oceans. Contaminated seed potatoes, nursery stock, and unwashed agricultural machinery have facilitated their introduction into new regions worldwide.

240. (C) Lack of oxygen and host plant roots
The vertical distribution of terrestrial nematodes is restricted in deeper soil horizons by physical and biological barriers. As soil depth increases, compaction and water saturation deplete oxygen levels, preventing aerobic respiration. Furthermore, the lack of host plant roots and organic matter deprives parasitic and free-living species of the energy resources needed to survive.

NODIA

241. (B) It acts as a metabolic sink funneling nutrients to the nematode
The giant cell complex induced by Meloidogyne is a specialized physiological adaptation. By injecting effector proteins, the nematode induces host cells to undergo repeated nuclear division, creating multinucleate cells with high metabolic activity. These giant cells act as localized metabolic sinks, continuously drawing sugars and nutrients from the plant to feed the parasite.

242. (D) Average number of female offspring produced per female at age x
In a biological life table, the age-specific fecundity column designated as m_x records reproduction. It measures the average number of female offspring produced per female within a specific age interval x. This metric, combined with survivorship data, is essential for calculating net reproductive rates and predicting the future growth of the population.

243. (A) Earlier and more severe wilt symptoms than if fungus was alone
Concomitant infection of roots by plant-parasitic nematodes and vascular wilt fungi typically triggers synergistic disease severity. The feeding activity of the nematodes wounds the root cells and compromises host defenses, creating entry

281. (D) Cyclical host growth combined with seasonal temperature changes
Seasonal fluctuations in agricultural nematode populations are primarily driven by host crop growth and seasonal temperature variations. Warm spring and summer temperatures accelerate metabolic rates and reproduction, while growing crops provide abundant food. In fall and winter, declining temperatures and host harvest trigger mortality and dormancy, causing populations to drop.

282. (A) Logistic growth model
The logistic growth model is the primary mathematical representation of population growth in a limited environment. Unlike exponential models, it incorporates a carrying capacity parameter that represents environmental resistance. This variable slows the growth rate as the population size increases, causing the curve to flatten and stabilize at a sustainable level.

283. (B) Endoparasites fully enter host tissue; ectoparasites feed from outside
The fundamental difference between these two parasitic strategies lies in their physical relationship with host roots. Endoparasites enter the root tissue completely, feeding and completing their lifecycle inside, causing cellular necrosis or establishing specialized feeding sites. In contrast, ectoparasites remain outside the root, inserting only their long stylets into cells from the soil.

284. (B) High populations of antagonistic fungi and bacteria
Natural suppression in "suppressive soils" is primarily driven by biological factors. These soils harbor high populations of antagonistic microorganisms, such as nematophagous fungi and parasitic bacteria. These natural enemies actively trap, infect, or parasitize nematodes and their eggs, keeping pest densities below damage thresholds even in the presence of susceptible crops.

285. (A) Species establish feeding sites in separate root tissue zones
Niche partitioning is an evolutionary mechanism that minimizes competitive exclusion among co-occurring plant-parasitic nematode species. This partitioning is clearly demonstrated when different species establish feeding sites in separate spatial zones, such as one feeding exclusively on root tips while another targets mature cortical tissue, allowing both populations to coexist.

286. (B) High early mortality with long lifespan for survivors
In demographic life table analysis, a Type III survivorship curve represents a specific mortality pattern. This curve indicates that the population experiences extremely high mortality rates during early juvenile stages, with only a small percentage of individuals surviving to adulthood. However, those individuals that survive enjoy a relatively long lifespan.

287. (D) Coarse, well-aerated sandy soil with adequate moisture
Coarse, well-aerated sandy soils with adequate moisture provide the ideal physical environment for root-knot nematodes. The large pore spaces accommodate the active movement of nematode juveniles, while optimal aeration sustains high aerobic respiration rates. This open soil structure facilitates rapid host root location, penetration, and infection, leading to high pest populations.

NODIA

288. (C) Environmental disturbance and ecosystem successional status
The primary advantage of calculating the Maturity Index is that it provides a quantitative measure of soil ecosystem health. By weighting nematode taxa based on their sensitivity to stress, this index reflects environmental disturbance and successional status. A high index indicates a stable, mature ecosystem, while a low index signals elevated disturbance.

289. (B) r
In the exponential population growth equation, the variable r is the intrinsic rate of natural increase. This parameter dictates the growth speed under ideal, unlimited environmental conditions. It represents the maximum potential increase per individual, reflecting the biological reproductive capacity of the species when resource limitations and environmental resistance are absent.

290. (B) Large, k-selected omnivores and predators (c-p 4 and 5)
Anthropogenic disturbances like heavy rotary tillage physically disrupt the soil matrix, tearing structured pore networks. This mechanical shear directly and negatively impacts large, K-selected omnivorous and predatory nematodes. Because

these species have long lifespans, low reproduction, and rely on stable habitats, tillage decimates their populations, shifting communities toward opportunists.

291. (C) A microbivore maintaining stable populations under moderate fluctuation
On the colonizer-persister scale, nematodes assigned a score of two are typically classified as competitive microbivores. These organisms exhibit stable populations under moderate environmental fluctuations, possessing intermediate lifespans and reproductive rates. They are less opportunistic than c-p one bacterivores, helping maintain structural balance and nutrient cycling within the soil food web.

292. (C) Overcrowding and depletion of food resources
The formation of the specialized dauer larva stage in bacterivorous nematodes is an ecological survival response. When soil environments experience extreme overcrowding, food depletion, and high concentrations of population pheromones, the developing juvenile halts normal development. It forms a highly resistant, non-feeding dauer larva adapted to survive until favorable conditions return.

293. (A) Bodies swell to a globose shape for massive egg production
Female sedentary endoparasites undergo a dramatic morphological transition as an adaptation to their lifestyle. After establishing a permanent feeding site inside host roots, they lose mobility, and their bodies swell to a swollen, globose shape. This physical expansion accommodates highly developed ovaries, allowing the stationary female to maximize reproductive output.

294. (D) The total count of unique species identified in a sample
In community ecology, species richness is a fundamental diversity index defined as the total count of unique species identified within a specific sample. While it provides a basic measure of taxonomic variety, it does not account for the relative abundance or evenness of individuals among those species, requiring additional indices for complete analysis.

295. (B) An antimicrobial barrier protecting eggs from desiccation
The gelatinous matrix secreted by root-knot nematode females is a vital evolutionary survival adaptation. Enclosing the egg mass outside the root, this sticky, complex barrier acts as a protective shield. It prevents the eggs from drying out in dry soils and serves as an antimicrobial barrier, protecting offspring from soil-borne pathogens.

296. (C) Initial nematode density (P_i) on a logarithmic scale
When plotting the mathematical relationships of the Seinhorst damage model, the independent variable is represented on the x-axis. This axis displays the initial nematode density at planting, typically plotted on a logarithmic scale. This scale accommodates wide variations in nematode abundance, from low densities to extremely high populations.

297. (B) c-p 1 and 2 nematodes
Highly disturbed agricultural soils, characterized by frequent tillage, compaction, or chemical application, favor resilient species. These physical stresses eliminate sensitive, long-lived persisters, leaving the community dominated by opportunistic c-p one and two nematodes. These fast-reproducing microbivores adapt quickly to disturbances, multiplying rapidly to exploit sudden resource availability.

298. (A) Parthenogenesis, polyphagy, and efficient anhydrobiotic survival
The exceptional global invasion success of root-knot nematodes is driven by a suite of adaptive life-history traits. Their ability to reproduce via mitotic parthenogenesis allows a single female to initiate infestations. Combined with an extremely broad host range and efficient survival strategies like anhydrobiosis, these parasites successfully colonize diverse agricultural ecosystems.

299. (B) Compensatory growth cannot overcome damage by increasing populations
Conceptually, the Tolerance Limit represents the threshold where a plant's physiological limits are reached. Below this nematode density, the crop utilizes root regeneration to offset parasite damage. However, once the initial population exceeds this limit, compensatory growth can no longer overcome the extensive root destruction, marking the start of detectable yield loss.

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300. (B) Fast-growing bacterivores responding to nutrient pulses

The Enrichment Index is driven upward by a rapid increase in fast-growing, opportunistic bacterivorous nematodes. When organic amendments or fertilizers are added to soil, they trigger rapid bacterial blooms. These microbivores, possessing low colonizer-persister values, respond explosively, multiplying quickly to consume the abundant bacteria, reflecting a highly enriched soil nutrient status.

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NODIA

(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

41. How does the transmission dynamics of seed gall nematodes fundamentally differ from typical below-ground parasites?
(A) Dissemination through contaminated seeds
(B) They rely exclusively on wind for dispersal
(C) They infect plants solely through insect vectors
(D) They require a fungal intermediate host to survive

2004

42. Which physiological adaptation is critical for above-ground nematodes to survive long periods without a host?
(A) Formation of protective cysts
(B) Extreme anhydrobiosis
(C) Secretion of a hardened gelatinous matrix
(D) Development of highly sclerotized stylets

2024

43. Ditylenchus dipsaci is widely recognized for causing severe damage to which type of plant structure?
(A) Deep taproots
(B) Xylem vessels
(C) Bulbs and stems
(D) Seed coats

2017

44. What defines the primary route of entry for foliar nematodes (Aphelenchoides spp.) into the leaf tissue?
(A) Direct mechanical penetration of the upper epidermis
(B) Entry through natural openings such as stomata
(C) Penetration exclusively through root hairs followed by upward migration
(D) Entry facilitated by vector feeding wounds

2008

45. Which of the following best describes the ecological environment below-ground nematodes must navigate compared to above-ground nematodes?
(A) High UV radiation and extremely low moisture levels
(B) Complex pore space, moisture, and root exudate gradients
(C) Extreme temperature fluctuations and high oxygen levels
(D) Complete absence of competing soil-borne microorganisms

2019

46. Above-ground nematodes typically exhibit which of the following characteristics?
(A) Permanent loss of motility after the initial infection
(B) Retention of a vermiform shape throughout the life cycle
(C) Induction of multinucleate giant cells in foliar tissues
(D) Complete lack of an oesophageal stylet for feeding

2011

47. Which physical symptom is most commonly associated with stem nematode (Ditylenchus) infection?
(A) Massive and widespread root galling
(B) Stem swelling, twisting, and distortion
(C) Rapid defoliation of lower plant leaves
(D) Woody stem necrosis and bark decay

2022

48. Below-ground parasitism by sedentary nematodes relies heavily on manipulating root vascular tissue because:
(A) It is the only tissue soft enough for them to penetrate
(B) It provides a supply of water and photosynthates
(C) It shields the nematode from various soil-borne fungi
(D) It lacks any constitutive or induced defense mechanisms

2006

49. The physical process of nematode penetration into a host root cell wall involves:
(A) Rapid and continuous rotation of the nematode body
(B) Stylet thrusting coupled with chemical degradation
(C) Excretion of strong acids to dissolve the epidermis
(D) Use of specialized cutting mandibles and labial teeth

2021

50. Match the following structures (List I) with their functions (List II).
List I: Structure
P. Subventral glands
Q. Dorsal gland

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(B) Ectoparasitism
(C) Migratory endoparasitism
(D) Semi-endoparasitism

2019

10. In the evolutionary progression toward sedentary plant parasitism, which of the following represent more primitive ancestral feeding behaviors?
I. Grazing on root hairs
II. Establishment of permanent feeding sites
III. Transient penetration of cortical cells
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2013

11. Which factor most likely drove the evolution of host specificity in plant-parasitic nematodes?
(A) Co-evolution with plant defense mechanisms
(B) Random genetic drift in soil populations
(C) Uniform root structures across diverse plant families
(D) Predation pressure from soil microarthropods

2001

12. The presence of a highly developed subventral gland in early-stage juveniles indicates an evolutionary adaptation for which process?
(A) Reproduction
(B) Digestion of internal plant tissues
(C) Penetration of the host cell wall
(D) Maintenance of the feeding site

2021

13. Which of the following defines an ectoparasitic plant nematode?
(A) It fully enters the host root to feed and reproduce
(B) It partially embeds its body into the root cortex
(C) It feeds exclusively on aerial plant parts and buds
(D) It feeds externally on the root using its stylet

2007

14. Which genus exemplifies a sedentary semi-endoparasitic feeding habit?
(A) Pratylenchus
(B) Xiphinema
(C) Tylenchulus
(D) Meloidogyne

2017

15. What distinguishes migratory endoparasites from sedentary endoparasites?
(A) They lose all motility after initial entry into the root
(B) They remain mobile and destroy cells as they feed
(C) They establish permanent and specialized feeding cells
(D) They feed exclusively on the surface hairs of roots

2017

16. Which nematode genus is classified as a migratory endoparasite?
(A) Heterodera
(B) Globodera
(C) Rotylenchulus
(D) Radopholus

NODIA

2018

17. The feeding habit of the dagger nematode (Xiphinema spp.) is best classified as:
(A) Migratory ectoparasite
(B) Sedentary endoparasite
(C) Semi-endoparasite
(D) Migratory endoparasite

2006

18. Which of the following statements regarding semi-endoparasites is INCORRECT?
(A) Only the anterior portion of their body is embedded in host tissue
(B) They frequently induce specialized and permanent feeding sites
(C) They are completely enveloped by host tissue throughout life
(D) They retain an external posterior portion for egg deposition

2003

19. Identify the correct pair of nematode genus and its feeding classification.
(A) Pratylenchus - Migratory endoparasite
(B) Meloidogyne - Migratory endoparasite
(C) Trichodorus - Sedentary endoparasite
(D) Tylenchulus - Migratory ectoparasite

2008

20. Consider the following statements regarding nematode classification:
I. Ectoparasites rarely cause mechanical damage to roots.
II. Endoparasites complete their life cycle entirely inside the plant.
III. Semi-endoparasites never induce localized swelling.
IV. Sedentary nematodes lose their vermiform shape at maturity.

breach
(C) Sampling of cell contents and salivary secretion
(D) Immediate deposition of an egg

2004

60. Select the correct sequence arranging the progression of structural damage during endoparasite migration.
I. Rupture of plasma membrane
II. Degradation of the middle lamella
III. Penetration of the primary cell wall
IV. Cellular necrosis
(A) II, III, I, IV
(B) III, II, I, IV
(C) I, III, II, IV
(D) III, I, II, IV

2014

61. Oesophageal gland secretions in plant-parasitic nematodes are primarily composed of:
(A) Structural carbohydrates
(B) Effector proteins and hydrolytic enzymes
(C) Toxic secondary metabolites like alkaloids
(D) Simple sugars and lipids

2008

62. Which gland is predominantly active during the establishment and maintenance of the feeding site in sedentary nematodes?
(A) Subventral gland
(B) Dorsal gland
(C) Excretory gland
(D) Rectal gland

2004

63. Cellulases secreted by plant-parasitic nematodes represent a significant evolutionary novelty because:
(A) They are synthesized in the nematode reproductive tract
(B) They are acquired through horizontal gene transfer
(C) They are entirely composed of complex RNA molecules
(D) They only function at highly alkaline pH levels in soil

2011

64. What is the primary role of pectate lyases secreted by invading nematodes?
(A) To degrade the plant cell nucleus and DNA
(B) To break down pectin in the middle lamella
(C) To synthesize new nematode cuticles during molting
(D) To inhibit host photosynthetic pathways systemically

2009

65. Consider the following statements regarding nematode effectors:
I. They are delivered into host cells via the stylet.
II. They can manipulate host gene expression.
III. They are exclusively produced by the subventral glands.
IV. They often suppress plant defense responses.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I, II and III

2019

66. The formation of a "feeding tube" is a result of secretions from which structure?
(A) The phasmids
(B) The oesophageal glands
(C) The amphids
(D) The excretory pore

2017

67. Which effector target demonstrates the ability of nematodes to manipulate host cell developmental pathways?
(A) Chloroplast degradation enzymes
(B) Host cell cycle regulators
(C) Root hair elongation genes exclusively
(D) Stomatal closure mechanisms

2025

68. The "parasitome" refers to:
(A) The complete set of plant genes affected by a nematode
(B) The entire repertoire of secreted effector proteins from a parasite
(C) The specialized feeding structure formed in the root
(D) The microbial community living on the nematode cuticle

2025

69. Which type of enzyme is typically abundant in subventral gland secretions during the tissue migration phase?
(A) DNA polymerases
(B) Cell-wall degrading enzymes (CWDEs)
(C) Nitrogenases
(D) Ribosomes

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(B) I and III
(C) III and IV
(D) I and V

2016

31. The term "vermiform" describes the shape of which specific developmental stage in Meloidogyne species?
(A) Mature adult female within the root tissue
(B) Infective second-stage juvenile
(C) Secreted gelatinous egg mass
(D) Developing fourth-stage female juvenile

2015

32. Which phenomenon is an adaptation of migratory nematodes to fluctuating soil environments?
(A) Rapid induction of multinucleate giant cells
(B) Ability to exit the root when resources deplete
(C) Transformation of the body wall into a protective cyst
(D) Complete dependence on a single plant cell for nutrition

2001

33. In the life cycle of Rotylenchulus reniformis, which stage is responsible for root penetration?
(A) Second-stage juvenile
(B) Mature male
(C) Immature female
(D) First-stage juvenile

2022

34. What dictates the sexual differentiation in some populations of Root-knot nematodes?
(A) Soil pH levels measured in agricultural fields
(B) Temperature variations during egg incubation periods
(C) Presence of specific bacterial endosymbionts in soil
(D) Host plant nutritional status and population density

2023

35. Which reproductive strategy is most common in economically important Meloidogyne species?
(A) Obligate amphimixis
(B) Hermaphroditism
(C) Mitotic parthenogenesis
(D) Meiotic diploidy

2017

36. What is the primary function of the gelatinous matrix produced by root-knot and reniform nematodes?
(A) To dissolve and weaken host cell walls
(B) To protect eggs from desiccation and microbes
(C) To facilitate juvenile migration through dense soil
(D) To attract males for the purpose of fertilization

2004

37. Which nematode genus is primarily known for parasitizing above-ground plant parts such as leaves and buds?
(A) Aphelenchoides
(B) Radopholus
(C) Meloidogyne
(D) Globodera

2018

38. The seed gall nematode, Anguina tritici, primarily infects which part of the host plant during its initial migratory phase?
(A) The mature grain before harvest
(B) The root elongation zone of seeds
(C) The senescent lower leaves of plants
(D) The apical meristem of the seedling

2019

39. Match the following nematodes (List I) with their primary parasitism site (List II).
List I: Nematode
P. Ditylenchus dipsaci
Q. Aphelenchoides ritzemabosi
R. Radopholus similis
S. Heterodera avenae
List II: Primary Parasitism Site
1. Roots (Endoparasite)
2. Roots (Sedentary)
3. Stems and bulbs
4. Foliar tissues
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

NODIA

2001

40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Above-ground nematodes like Aphelenchoides often require a film of water on plant surfaces for infection.
Reason (R): They lack the muscular strength to penetrate dry epidermal layers and rely on swimming to reach stomata or wounds.
(A) Both A and R are true and R is the correct explanation of A.

(A) A single, massively enlarged cell
(B) Exactly two paired cells
(C) Usually 5 to 7 discrete giant cells
(D) Over 100 fused cells

2005

81. The process of endoreduplication in giant cells refers to:
(A) The physical duplication of the outer cell wall
(B) Replication of the genome without nuclear division
(C) Division of the nucleus without subsequent cell division
(D) The fusion of two distinct and separate nuclei

2012

82. Which cellular component is notably reduced or completely absent in mature giant cells?
(A) Mitochondria
(B) Endoplasmic reticulum
(C) Large central vacuole
(D) Ribosomes

2012

83. The continuous maintenance of a giant cell is dependent upon:
(A) The permanent presence of the male nematode in the root
(B) Continuous stimulus from the feeding female nematode
(C) The formation of a protective and hardened cyst wall
(D) The application of exogenous fertilizers to the host plant

2007

84. When a nematode dies or is removed, the associated giant cell typically:
(A) Differentiates back into a normal root cell
(B) Undergoes rapid senescence and collapses
(C) Continues to grow independently
(D) Transforms into a meristematic stem cell

2009

85. Syncytia, induced by cyst nematodes, are formed through which fundamental cellular mechanism?
(A) Acytokinetic mitosis occurring in a single cell
(B) Wall dissolution and fusion of adjacent protoplasts
(C) Uncontrolled cell division resulting in a tumorous growth
(D) Hypertrophy of epidermal cells in the root elongation zone

2014

86. Which nematode genus is primarily associated with syncytium formation?
(A) Meloidogyne
(B) Heterodera
(C) Radopholus
(D) Tylenchulus

2005

87. What is a key structural difference between a syncytium and a giant cell?
(A) A syncytium lacks nuclei throughout its development
(B) A syncytium is formed from cell fusion with wall remnants
(C) A syncytium does not function as a transfer cell
(D) A giant cell is formed exclusively in the phloem tissue

2005

88. The initial cell selected by an infective cyst nematode juvenile to begin syncytium formation is termed the:
(A) Initial syncytial cell (ISC)
(B) Primary meristem cell
(C) Central giant cell
(D) Foundation transfer cell

2022

89. Which structural feature is prominent within a mature syncytium?
(A) Large, intact central vacuoles in every fused cell component
(B) Dense cytoplasm with organelles and plastids
(C) Complete lignification of the outer boundary wall structures
(D) Absence of any functional cell wall ingrowths for transport

2024

90. The breakdown of cell walls during syncytium formation is facilitated by nematode-secreted enzymes and:
(A) High internal pressure bursting the cell walls
(B) Activation of endogenous plant wall-degrading enzymes
(C) Mechanical destruction by the nematode's stylet
(D) Acidification of the entire root system's soil matrix

2001

91. Match the feeding site characteristics (List I) with the corresponding nematode type (List II).
List I: Feeding Site Characteristic

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R. Stylet
S. Amphids
List II: Function
1. Chemosensory perception of root exudates
2. Physical puncturing of cell walls
3. Secretion of enzymes during initial penetration
4. Secretion of effectors for feeding site maintenance
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2012

51. Intracellular migration of infective juveniles in root tissue primarily causes which type of damage?
(A) Immediate and widespread systemic wilting
(B) Hyperplasia of all cortical cells in roots
(C) Mechanical destruction of cells along the path
(D) Dissolution of the entire root endodermis layer

2003

52. Select the correct sequence of events during root penetration and migration by an infective Meloidogyne juvenile.
I. Migration toward the root tip via exudate gradients.
II. Intercellular migration to the vascular cylinder.
III. Penetration of the epidermal cells behind the root cap.
IV. Selection of a specific provascular host cell.
(A) I, II, III, IV
(B) I, III, II, IV
(C) III, I, IV, II
(D) II, I, III, IV

2023

53. Which anatomical feature provides the mechanical leverage necessary for a nematode to thrust its stylet into a plant cell?
(A) Hydrostatic pressure of the pseudocoelom
(B) Flexible nature of the copulatory spicules
(C) Specialized and reinforced lip region
(D) Rigid structure of the muscular metacorpus

2025

54. How does cyst nematodes (Heterodera spp.) typically migrate through the root cortex?
(A) Exclusively intercellularly, separating cell walls
(B) Exclusively via the primary xylem vessel elements
(C) Intracellularly, causing significant cellular damage
(D) Through the phloem sieve tubes and companion cells

2011

55. What is the role of the cephalic framework during mechanical penetration?
(A) It produces the necessary hydrolytic enzymes
(B) It provides support for stylet muscle contraction
(C) It secretes the feeding tube for nutrient uptake
(D) It senses soil temperature and moisture gradients

2010

56. Which of the following statements regarding stylet structure and function is correct?
(A) The odontostylet is hollow, while the stomatostylet is solid
(B) The stomatostylet is characterized by basal knobs for muscle attachment
(C) Only endoparasites possess a functional stylet
(D) Stylet thrusts are purely mechanical and lack chemical coordination

2022

57. The primary barrier a nematode must breach during initial mechanical penetration of a root is the:
(A) The Casparian strip in the endodermis
(B) The pericycle layer of the root cylinder
(C) Epidermal cell wall and surface cuticle
(D) The vascular cambium in the inner root

2011

58. Intercellular migration, as opposed to intracellular migration, is characterized by:
(A) Secretion of enzymes that dissolve the middle lamella
(B) Complete destruction of host cell cytoplasm
(C) Rapid and widespread death of the host plant
(D) Penetration through the nucleus of the host cell

2008

59. What behavior is typically observed immediately after a nematode breaches a host cell wall but before full entry?
(A) Retraction of the stylet and resting
(B) Secretion of a hardened plug to seal the

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Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

2008

21. Which morphological characteristic is most common in mature female sedentary endoparasites?
(A) Elongated, slender body
(B) Swollen, globose or pear-shaped body
(C) Highly active sensory organs
(D) Enlarged tail structure for movement

2007

22. In the context of feeding classification, which term best describes nematodes that feed sequentially on multiple epidermal cells without entering the root?
(A) Sedentary ectoparasites
(B) Grazing endoparasites
(C) Migratory ectoparasites
(D) Obligate semi-endoparasites

2009

23. What is the primary ecological advantage of the sedentary endoparasitic habit?
(A) Avoiding competition with other soil microorganisms
(B) Rapid spread across multiple host plants
(C) Evasion of soil-borne chemical nematicides
(D) Continuous access to a sustained nutrient sink

2001

24. Which of the following nematodes belongs to the category of sedentary endoparasites?
(A) Globodera
(B) Belonolaimus
(C) Helicotylenchus
(D) Hoplolaimus

2009

25. Which life cycle stage is typically the infective stage for sedentary endoparasites like Root-knot nematodes?
(A) First-stage juvenile
(B) Second-stage juvenile
(C) Third-stage juvenile
(D) Adult female

2005

26. In migratory endoparasites such as Pratylenchus, which stages are capable of infecting the host?
(A) Only the second-stage juveniles
(B) All juvenile stages and adults
(C) Only adult females
(D) Only the eggs

2025

27. What is a key life cycle adaptation of the cyst nematode (Heterodera spp.) to survive adverse conditions?
(A) Retention of eggs within the tanned cyst of the dead female
(B) Formation of an anhydrobiotic adult male to resist drought
(C) Encystment of the first-stage juvenile in the soil matrix
(D) Diapause occurring exclusively at the adult female stage

2016

28. Which developmental event occurs prior to hatching in most plant-parasitic nematodes?
(A) Second molt inside the egg
(B) Development of functional reproductive organs
(C) First molt inside the egg
(D) Shedding of the external cuticle

NODIA

2023

29. How does the feeding strategy of sedentary nematodes influence their reproductive output compared to migratory species?
(A) Sedentary species produce significantly fewer eggs annually
(B) Migratory species lay eggs in specialized protective cysts
(C) Reproductive output is identical regardless of feeding strategy
(D) Sedentary species generally have a higher reproductive rate

2017

30. Consider the following statements regarding sedentary nematode life cycles:
I. Males are typically vermiform.
II. Females retain mobility after the fourth molt.
III. Second-stage juveniles are the primary migratory phase.
IV. Feeding site establishment halts further migration.
V. Parthenogenesis is absent in all sedentary species.
Which of the above statement(s) is/are INCORRECT?
(A) II and V

2017

70. How do some nematode effectors prevent localized cell death (HR) in the host plant?
(A) By directly killing the plant cells before they can react
(B) By suppressing immune signaling and ROS production
(C) By strengthening the plant cell wall against mechanical stress
(D) By inducing rapid abscission of the infected root tissues

2010

71. The presence of chorismate mutase in nematode secretions is significant because it:
(A) Directly digests host cellulose in the cell wall
(B) Alters the plant's shikimate pathway and defenses
(C) Forms the structural basis of the feeding tube
(D) Induces immediate host cell apoptosis and death

2003

72. Which term best describes the spatial destination of effectors injected into a host cell by a sedentary nematode?
(A) The extracellular space and the rhizospheric zone
(B) The apoplast exclusively to avoid detection
(C) Cytoplasm and eventually the host cell nucleus
(D) Xylem vessels only for systemic translocation

2007

73. Giant cells induced by root-knot nematodes are characterized by which defining cellular feature?
(A) Complete lack of a nucleus
(B) Being multinucleate due to acytokinetic mitosis
(C) Being formed by the dissolution of cell walls between adjacent cells
(D) Having thickened, highly lignified secondary walls

2010

74. Which physiological process drives the immense size increase of a giant cell?
(A) Massive influx of water through aquaporins only
(B) Repeated DNA synthesis without cytokinesis
(C) Fusion of hundreds of neighboring epidermal cells
(D) Secretion of large lipid droplets by the nematode

2003

75. The dense, granular cytoplasm of a giant cell is primarily indicative of:
(A) Cell senescence and approaching localized death
(B) High metabolic activity and abundant organelles
(C) Accumulation of toxic waste and secondary products
(D) Viral co-infection with soil-borne pathogens

2004

76. What structural modification occurs in the cell walls of giant cells adjacent to vascular elements?
(A) Complete dissolution and loss of integrity
(B) Formation of extensive cell wall ingrowths
(C) Heavy suberization of the vascular elements
(D) Deposition of thick cutin layers for protection

2001

77. The cell wall ingrowths in giant cells serve what primary biological function?
(A) Physical defense against the nematode stylet
(B) Increasing surface area for solute uptake
(C) Trapping the nematode in place within the cell
(D) Preventing the escape of cytoplasmic organelles

2021

78. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Giant cells function as specialized transfer cells.
Reason (R): They develop complex cell wall ingrowths that maximize the transport of nutrients from the xylem.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

79. Which nematode genus is exclusively associated with the induction of true giant cells?
(A) Heterodera
(B) Meloidogyne
(C) Globodera
(D) Pratylenchus

2005

80. How many giant cells typically comprise a single root-knot nematode feeding site?

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CHAPTER 05
Plant Nematode Relationships

2006

1. Which hypothesis best explains the evolutionary origin of plant parasitism in nematodes?
(A) Evolution from fungivorous ancestors within the soil ecosystem
(B) Divergence exclusively from marine vertebrate parasites
(C) Direct evolution from obligate entomopathogenic species
(D) Spontaneous mutation in aquatic free-living nematodes

2001

2. What morphological adaptation is primarily associated with the evolutionary shift to plant parasitism in nematodes?
(A) Development of a hardened cuticle
(B) Loss of the metacorpus
(C) Acquisition of a protrusible stylet
(D) Reduction in the number of sensory amphids

2024

3. In the context of nematode evolution, which ecological shift facilitated adaptation to plant roots?
(A) Transition from consuming soil bacteria to plant cells
(B) Movement from anaerobic to aerobic soil layers for survival
(C) Transition from a strictly aquatic to a moist soil micro-environment
(D) Adaptation to high salinity in coastal agricultural lands and estuaries

2013

4. Which feature is considered a convergent evolutionary trait among phylogenetically distinct plant-parasitic nematode lineages?
(A) Widespread use of parthenogenetic reproduction
(B) Complex formation of multinucleate giant cells
(C) Complete evolutionary loss of the nervous system
(D) Presence of a stomatostylet or odontostylet

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2007

5. The evolutionary transition to a sedentary lifestyle in nematodes is most strongly correlated with which physiological change?
(A) Significantly increased motility of adult females
(B) Enlargement of oesophageal glands for effector secretion
(C) Progressive regression of the reproductive system
(D) Extensive loss of chemical signaling pathways

2008

6. Which group of nematodes represents a transitional evolutionary stage between free-living and obligate plant-parasitic forms?
(A) Tylenchida
(B) Dorylaimida
(C) Aphelenchida
(D) Rhabditida

2024

7. The horizontal gene transfer (HGT) from bacteria to nematode genomes primarily provided genes coding for which type of enzymes?
(A) Proteases
(B) Lipases
(C) Amylases
(D) Cellulases

2007

8. In evolutionary terms, why is parasitism considered an advanced ecological strategy for nematodes?
(A) It provides a stable, nutrient-rich environment
(B) It significantly reduces dependence on environmental moisture
(C) It effectively eliminates the need for further reproduction
(D) It broadens the host range to include both plants and animals

2010

9. Which feeding strategy is considered the most evolutionarily primitive among plant-parasitic nematodes?
(A) Sedentary endoparasitism

P. Originates by cell fusion
Q. Originates by acytokinetic mitosis
R. Formed by Heterodera
S. Formed by Meloidogyne

List II: Type
1. Syncytium
2. Giant Cell
3. Syncytium
4. Giant Cell

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-2, S-1
(C) P-1, Q-2, R-2, S-1
(D) P-2, Q-1, R-1, S-2

2007

92. Syncytia established in resistant plant varieties typically exhibit which outcome?
(A) Uncontrolled and massive growth of the syncytium
(B) Early degradation preventing nematode maturation
(C) Transformation into giant cells in certain cultivars
(D) Immediate conversion to hardened and woody tissue

2008

93. How does the size of a syncytium generally correlate with nematode development?
(A) There is no known correlation between these variables
(B) Males require larger syncytia than developing females
(C) Females require larger syncytia to complete reproduction
(D) Syncytia shrink significantly as the nematode grows larger

2015

94. The continuous expansion of a syncytium involves the incorporation of which types of cells?
(A) Epidermal cells exclusively during initial entry
(B) Neighboring vascular parenchyma and endodermal cells
(C) Root cap cells during the early migratory phase
(D) Apical meristem cells during rapid root elongation

2023

95. What role do plasmodesmata play during the very early stages of syncytium formation?
(A) They are immediately sealed to isolate the infected cell
(B) They undergo targeted widening before wall dissolution
(C) They are transformed into highly lignified pore structures
(D) They secrete defensive toxins into the neighboring cells

2006

96. Which term accurately describes the nuclear state of a fully developed syncytium?
(A) Anucleate
(B) Uninucleate and diploid
(C) Multinucleate and hypertrophied
(D) Binucleate and haploid

2017

97. The most iconic macroscopic symptom of Meloidogyne infection is:
(A) Stunted roots with dark lesions
(B) Pronounced root galling or knotting
(C) Excessive root hair proliferation
(D) Total absence of lateral roots

2009

98. Root galling is primarily the result of which two host responses?
(A) Hyperplasia and hypertrophy of cortical cells
(B) Necrosis and apoptosis of vascular tissue
(C) Lignification and suberization of the epidermis
(D) Plasmolysis and desiccation of the endodermis

2006

99. "Stubby root" symptoms, characterized by short, thickened root branches, are typically caused by which nematode?
(A) Trichodorus
(B) Pratylenchus
(C) Radopholus
(D) Globodera

2002

100. Microscopic examination of roots infected by Pratylenchus spp. generally reveals:
(A) Large, multinucleate giant cells within the root cortex
(B) Extensive dark, necrotic lesions in the root cortex
(C) Perfectly formed syncytia in the vascular cylinder
(D) Complete loss of root caps and apical meristematic cells

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(D) It detaches and floats in the host cytoplasm

2021

190. Match the defense response (List I) with its classification (List II).
List I: Defense Response
P. Lignin in root exodermis prior to infection
Q. Callose papillae formation
R. Alpha-tomatine in healthy roots
S. Localized apoptosis (HR)
List II: Classification
1. Constitutive structural
2. Induced structural
3. Constitutive chemical
4. Induced biochemical
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-1, Q-2, R-4, S-3
(D) P-2, Q-1, R-3, S-4

2023

191. THE browning associated with the HR is primarily due to the oxidation of which compounds?
(A) Breakdown of carbohydrates in the host cell
(B) Phenolics oxidized to toxic quinone compounds
(C) Oxidation of lipids in the cell membrane
(D) Breakdown of amino acids in the cytoplasm

2024

192. Induced resistance responses are energy-intensive. Therefore, a plant typically activates them:
(A) Continuously from germination of the host
(B) After specific recognition of PAMPs or effectors
(C) Only during nighttime hours for energy saving
(D) Only during the flowering stage of development

2014

193. Flor's gene-for-gene hypothesis, originally described in flax rust, states that an incompatible (resistant) interaction requires:
(A) Two R genes and two avirulence genes
(B) A dominant R gene and a matching Avr gene
(C) THE absence of genes in both organisms
(D) A dominant susceptible gene and virulence gene

2018

194. In the context of the gene-for-gene model applied to nematodes, what does the R gene product typically act as?
(A) A basic hydrolytic enzyme in the root
(B) A structural cell wall component in cells
(C) A receptor that recognizes the Avr protein
(D) A toxin that directly kills the nematode

2009

195. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): If a plant possesses the R gene but the nematode population has a mutated Avr gene, the plant will be susceptible.
Reason (R): THE mutation in the Avr gene prevents recognition by the plant's R protein, averting the activation of defense responses.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2010

196. THE majority of cloned plant resistance genes against nematodes encode proteins of which class?
(A) NBS-LRR (Nucleotide-Binding Site Leucine-Rich Repeat)
(B) Receptor-Like Kinases (RLKs) found in roots
(C) Polygalacturonase-Inhibiting Proteins (PGIPs)
(D) Chitinases produced after initial infection

2024

197. THE Leucine-Rich Repeat (LRR) domain of an R protein is primarily responsible for:
(A) Anchoring the protein in the host membrane
(B) Protein-protein interaction and recognition
(C) Binding ATP to provide energy for the plant
(D) Direct destruction of nematode DNA molecules

2013

198. THE "Guard Hypothesis" is an extension of the gene-for-gene model suggesting that:
(A) THE R protein guards the plant nucleus
(B) R protein monitors a host target protein
(C) THE R protein is secreted into the soil
(D) Nematodes secrete guards for their effectors

2022

113. Seed galls, wherein normal seed grains are replaced by dark, hardened masses of nematodes, are caused by:
(A) Heterodera avenae
(B) Anguina tritici
(C) Meloidogyne graminicola
(D) Pratylenchus penetrans

2013

114. Which pattern of symptom distribution in a field is highly indicative of a nematode infestation?
(A) Uniform symptoms across the entire field
(B) Symptoms appearing exclusively on field edges
(C) Localized patches of stunted, yellowing plants
(D) Perfect circular patterns from a single plant

2012

115. Reduced yield and poor quality of harvestable produce due to nematodes are classified as:
(A) Direct primary symptoms observed
(B) Microscopic symptoms of the roots
(C) Quantitative systemic symptoms
(D) Pathognomonic signs of infection

2015

116. Stunting caused by nematode infection is often accompanied by which morphological change in the shoot?
(A) Increased internode length in the shoot
(B) Reduced internode length and delayed flowering
(C) Excessive branching from the primary stem
(D) Enlargement of apical buds and floral parts

2012

117. Consider the following statements regarding above-ground symptoms:
I. They are always a direct consequence of nematodes residing in the aerial tissues.
II. They often mimic symptoms of nutrient deficiency.
III. Midday wilting indicates compromised root function.
IV. Patchy distribution is common in nematode-infested fields.
V. Seed galls contain purely plant tissue.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) III, IV and V
(D) I, IV and V

2022

118. Which mineral deficiency symptom does root nematode damage most commonly mimic in plants?
(A) Nitrogen deficiency (generalized chlorosis)
(B) Calcium deficiency (blossom end rot)
(C) Boron deficiency (hollow heart)
(D) Molybdenum deficiency (whiptail)

2009

119. A field of wheat showing deformed, twisted leaves and stems, often termed "tulip root," is characteristic of infection by:
(A) Ditylenchus dipsaci
(B) Heterodera avenae
(C) Meloidogyne javanica
(D) Xiphinema index

2005

120. When diagnosing nematode issues based on above-ground symptoms, why is root examination essential?
(A) Non-specific and easily confused symptoms
(B) Nematodes move from leaves back to the roots
(C) Roots show visible galls regardless of species
(D) Symptoms only appear after the plant is dead

2012

121. In nematology, the term "pathotype" is specifically used to describe a population of a nematode species that:
(A) Differs morphologically from the type species
(B) Can overcome specific host resistance genes
(C) Has a completely different geographic origin
(D) Infects only animal hosts in the environment

2010

122. A "biotype" in nematodes generally refers to:
(A) A group sharing identical morphology
(B) A population with a specific trait
(C) A distinct and newly identified species
(D) Nematodes bred in artificial conditions

2006

123. The development of new physiological races or pathotypes in agricultural fields is primarily an evolutionary response to:
(A) Changes in soil temperature and acidity
(B) Intensive monoculture using R-gene cultivars
(C) Application of broad-spectrum nematicides
(D) Variations in annual rainfall and soil moisture

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2009

124. Which evolutionary mechanism is largely responsible for the rapid emergence of resistance-breaking pathotypes in parthenogenetic nematodes like Meloidogyne?
(A) Recombination during sexual reproduction
(B) Gene flow from neighboring populations
(C) Selection acting on pre-existing variation
(D) Interspecific hybridization between species

2011

125. The concept of a "physiological race" in root-knot nematodes is defined primarily by:
(A) Differences in the shape of the perineal pattern
(B) The ability to reproduce on differential hosts
(C) The size of the infective juvenile stage
(D) Differences in optimal temperature for hatching

2010

126. Why is pathotype designation crucial for nematode management?
(A) It dictates which chemical nematicide must be used
(B) It determines the appropriate cultivar to deploy
(C) It alters quarantine regulations internationally
(D) It indicates the exact harvest date of the crop

2025

127. Which genetic term describes the ability of a nematode pathotype to reproduce on a plant carrying a specific resistance gene?
(A) Avirulence
(B) Virulence
(C) Tolerance
(D) Susceptibility

2016

128. If a nematode population lacks the specific avirulence (Avr) gene recognized by the host's resistance (R) gene, the resulting interaction is:
(A) Incompatible (Nematode dies in root)
(B) Compatible (Reproduction occurs normally)
(C) Neutral (No infection occurs in soil)
(D) Mutualistic (Both species benefit well)

2016

129. The phenotypic plasticity observed in some nematode biotypes allows them to:
(A) Rapidly change their DNA sequence
(B) Adapt host preference based on cues
(C) Convert from a nematode to a fungus
(D) Survive temperatures above boiling

2024

130. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The widespread use of a single resistant cultivar can reduce the functional lifespan of that resistance gene in the field.
Reason (R): High selection pressure favors the survival and multiplication of rare, virulent nematode variants (pathotypes).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

131. Which scenario most likely accelerates the evolution of a new pathotype?
(A) Crop rotation with non-host species in soil
(B) Continuous planting of a highly resistant host
(C) Planting a universally susceptible host variety
(D) Use of organic soil amendments for management

2013

132. The distinction between races in Meloidogyne incognita relies on measuring which parameter on differential hosts?
(A) The physical length of the adults in roots
(B) Presence of root galling and reproduction
(C) The speed of root penetration by juveniles
(D) Amount of effector proteins secreted into cells

2006

133. The internationally recognized scheme for designating pathotypes of the potato cyst nematode, Globodera rostochiensis, utilizes which nomenclature system?
(A) Ro1, Ro2, Ro3, etc.
(B) Race 1, Race 2, Race 3
(C) Pa1, Pa2, Pa3
(D) Biotype A, B, C

2004

134. Which nomenclature denotes pathotypes of the white potato cyst nematode, Globodera pallida?
(A) Pr1, Pr2, Pr3
(B) Gp1, Gp2, Gp3
(C) Pa1, Pa2, Pa3

NODIA

(D) Ro1, Ro2, Ro3

2017

135. Differential host tests for potato cyst nematodes traditionally use clones from which plant genus?
(A) Solanum
(B) Lycopersicon
(C) Nicotiana
(D) Capsicum

2003

136. The British pathotype scheme for potato cyst nematodes was historically based on the response of resistance derived from:
(A) Solanum tuberosum ssp. tuberosum varieties
(B) Solanum tuberosum ssp. andigena varieties
(C) Solanum lycopersicum varieties grown in tropical soils
(D) Solanum melongena varieties grown in tropical soils

2023

137. Which of the following is considered the most globally widespread and economically important pathotype of Globodera rostochiensis?
(A) Ro5
(B) Ro3
(C) Ro1
(D) Ro4

2005

138. Pathotype classification in the cereal cyst nematode, Heterodera avenae, involves differential varieties of which crops?
(A) Potato, tomato, and eggplant
(B) Wheat, barley, and oats
(C) Soybean, dry bean, and cowpea
(D) Corn, sorghum, and millet

2019

139. The soybean cyst nematode, Heterodera glycines, is classified into races based on the reaction of how many standard soybean differential lines?
(A) Two
(B) Four
(C) Six
(D) Ten

2011

140. In modern nematology, the traditional "race" scheme for Heterodera glycines has largely been replaced by which more comprehensive classification system?
(A) The HG Type Test
(B) The SCN Pathotype Index
(C) The Globodera Equivalency Test
(D) The Resistance Gene Index (RGI)

2021

141. What is the fundamental difference between the HG Type test and the older race test for soybean cyst nematode?
(A) The HG Type test uses genetic sequencing methods
(B) HG Type shows which resistance sources are overcome
(C) The race test uses 10 differentials for classification
(D) There is no difference; they are exactly synonymous

NODIA

2011

142. A Globodera population that fails to produce cysts on Solanum tuberosum ssp. andigena but reproduces on standard susceptible potatoes is classified as:
(A) A virulent pathotype
(B) Pathotype Ro1 or Ro4
(C) Pathotype Pa2/3
(D) An entirely different genus

2019

143. Match the nematode (List I) with its standard pathotype/race classification scheme (List II).
List I: Nematode
P. Globodera rostochiensis
Q. Heterodera glycines
R. Meloidogyne incognita
S. Globodera pallida
List II: Classification Scheme
1. Pa1, Pa2, Pa3
2. Ro1, Ro2, Ro3
3. HG Type
4. Races 1, 2, 3, 4
(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-4, R-2, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-3, R-4, S-2

2002

144. In differential testing for cyst nematodes, what is typically counted to assess virulence?
(A) The number of root galls found on the plant
(B) Number of newly formed cysts per root system
(C) The length of the primary root system measured
(D) The percentage of dead plants in the greenhouse

2024

145. The North Carolina Differential Host Test is widely used to identify species and races within which nematode genus?
(A) Heterodera
(B) Pratylenchus
(C) Meloidogyne
(D) Xiphinema

2007

146. How many standard host plant species/cultivars comprise the original North Carolina Differential Host Test?
(A) Four
(B) Six
(C) Eight
(D) Ten

2006

147. Which of the following is NOT one of the standard plants used in the North Carolina Differential Host Test?
(A) Tobacco (cv. NC 95)
(B) Cotton (cv. Deltapine)
(C) Soybean (cv. Peking)
(D) Wheat (cv. PI 137739)

2022

148. According to the North Carolina test, Meloidogyne javanica is differentiated from most races of M. incognita by its inability to reproduce on:
(A) Tomato (cv. Rutgers)
(B) Watermelon (cv. Charleston Gray)
(C) Pepper (cv. California Wonder)
(D) Peanut (cv. Florunner)

2007

149. Which Root-knot nematode species is uniquely identified in the NC test by its ability to readily infect and reproduce on Peanut (cv. Florunner)?
(A) Meloidogyne incognita populations
(B) Meloidogyne javanica populations
(C) Meloidogyne arenaria (Race 1)
(D) Meloidogyne hapla populations

2015

150. How many distinct physiological races of Meloidogyne incognita are formally recognized using the North Carolina Differential Host Test?
(A) Two
(B) Three
(C) Four
(D) Five

2019

151. Race 1 of Meloidogyne incognita is characterized by a susceptible/resistant response (+/-) on which two key differentials?
(A) Tobacco (NC 95) (-) and Cotton (Deltapine) (-)
(B) Tobacco (NC 95) (+) and Cotton (Deltapine) (+)
(C) Tobacco (NC 95) (+) and Cotton (Deltapine) (-)
(D) Tobacco (NC 95) (-) and Cotton (Deltapine) (+)

2016

152. Which root-knot species is known for causing small, distinct galls with extensive lateral root proliferation, and typically infects peanut but not watermelon?
(A) Meloidogyne hapla
(B) Meloidogyne incognita
(C) Meloidogyne javanica
(D) Meloidogyne arenaria

2022

153. What is the main limitation of the North Carolina Differential Host Test in modern diagnostics?
(A) It requires expensive DNA sequencing equipment
(B) It takes 45-60 days and greenhouse space
(C) It only works for cyst nematodes in the soil
(D) It requires hazardous chemical reagents for tests

2021

154. To definitively separate Meloidogyne species rapidly today, the host differential test is often supplemented or replaced by:
(A) Staining with iodine for visualization
(B) Molecular and isozyme phenotyping
(C) Measuring nematode length under microscope
(D) Checking optimal soil pH for reproduction

2015

155. Which plant in the NC differential test serves as the universal susceptible check, confirming that the nematode inoculum is viable?
(A) Peanut (cv. Florunner)
(B) Cotton (cv. Deltapine)
(C) Tomato (cv. Rutgers)
(D) Tobacco (cv. NC 95)

2021

156. Consider the following statements regarding the North Carolina Differential Test:
I. It utilizes six specific plant cultivars.

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II. A rating of + (plus) indicates significant galling and reproduction.
III. It can identify specific races of M. arenaria.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2014

157. In the context of plant nematology, a host plant that allows heavy nematode reproduction while suffering severe damage is defined as:
(A) Resistant
(B) Susceptible
(C) Tolerant
(D) Intolerant

2021

158. How is a "resistant" plant strictly defined in relation to plant-parasitic nematodes?
(A) It exhibits no physical symptoms of damage
(B) It completely prevents nematode penetration
(C) It suppresses or prevents reproduction
(D) It kills all nematodes in the surrounding soil

2019

159. A plant variety that sustains high nematode reproduction but shows minimal yield loss or visible damage is referred to as:
(A) Susceptible
(B) Resistant
(C) Tolerant
(D) Immune

2002

160. Which term best describes a plant that suffers extreme damage or dies quickly upon nematode infection, ironically preventing the nematode from reproducing?
(A) Tolerant host plant
(B) Intolerant or hypersensitive plant
(C) Susceptible host plant
(D) Immune host plant

2007

161. Immunity in a plant, concerning nematode infection, means:
(A) Absolute non-host status for infection
(B) The nematode enters but is killed by HR
(C) The plant produces galls but no eggs are laid
(D) The plant yields well despite high populations

2002

162. Resistance and tolerance are genetically independent traits. This means a plant can be:
(A) Only resistant and intolerant cultivars
(B) Only susceptible and tolerant cultivars
(C) Both resistant and tolerant, or the inverse
(D) Neither resistant nor susceptible cultivars

2019

163. The primary goal of breeding for nematode resistance in agriculture is to:
(A) Eliminate the need for any water
(B) Reduce soil nematode population density
(C) Maximize root galling for study
(D) Create universal tolerance to all pathogens

2001

164. What is a potential agricultural drawback of planting a highly tolerant, but completely susceptible, crop variety?
(A) The crop will die before producing a yield
(B) It requires immense amounts of pesticides
(C) It builds up high soil populations
(D) It automatically turns into a weed

2003

165. The "host status" of a plant is primarily determined by evaluating which metric?
(A) Plant height
(B) Nematode reproduction factor
(C) Photosynthetic rate
(D) Soil nutrient depletion

2015

2021

166. A reproduction factor ($\frac{Pf}{Pi}$) of less than 1.0 ($Pf < \Pi$) indicates that the plant is generally:
(A) Susceptible
(B) A highly tolerant host
(C) Resistant or a poor host
(D) An optimal host

2022

167. Which of the following defines a "non-host" crop?
(A) Crop that does not support reproduction
(B) Crop that supports reproduction without loss
(C) Crop that only allows cyst nematodes to feed
(D) Crop that is killed instantly upon germination

2004

168. The relationship between resistance and hypersensitivity is that:
(A) Hypersensitivity is the only mechanism of tolerance
(B) It is a common post-infectional mechanism for resistance

NODIA

2003

101. Which symptom is best characterized as a reduction in the overall mass and length of the root system without specific deformities?
(A) Root knotting
(B) Root pruning
(C) Lesion formation
(D) Fasciation

2009

102. Nematodes feeding at root tips often cause a temporary cessation of growth, which leads to a macroscopic symptom known as:
(A) Tight coiling of the entire root system
(B) Root proliferation behind the root tip
(C) Root explosion and subsequent decay
(D) Stem galling in the lower aerial parts

2012

103. The physical presence of tiny, pearl-like structures protruding from the root surface is indicative of:
(A) Lesion nematode infection
(B) Cyst nematode adult females
(C) Stubby root nematode feeding
(D) Dagger nematode egg masses

2017

104. Arrange the sequence of microscopic symptom development following migratory endoparasite infection.
I. Breakdown of cell walls and contents
II. Initial cell penetration
III. Appearance of visible necrotic lesions
IV. Release of cellular contents and browning
(A) II, IV, I, III
(B) II, I, IV, III
(C) I, II, III, IV
(D) II, III, I, IV

2022

105. "Root pruning" is most typically associated with high population densities of:
(A) Ectoparasitic nematodes like Belonolaimus
(B) Root-knot nematodes infecting diverse hosts
(C) Foliar nematodes inhabiting the leaf tissue
(D) Stem and bulb nematodes causing distortions

2015

106. In addition to direct damage, necrotic lesions caused by nematodes frequently lead to which secondary issue?
(A) Enhanced and efficient nutrient uptake
(B) Increased frost and drought tolerance
(C) Secondary infection by soil-borne pathogens
(D) Rapid generation of adventitious roots

2004

107. Which cellular change is microscopic evidence of a successful hypersensitive response (HR) to a nematode?
(A) Rapid localized cell death and browning
(B) Formation of a massive giant cell
(C) Thickening of the root cap region
(D) Hypertrophy of neighboring healthy cells

2007

108. The term "hyperplasia" in the context of root galling refers to:
(A) An abnormal increase in cell volume
(B) An abnormal increase in the number of cells
(C) The death of specific host cell layers
(D) The breakdown of stored starch granules

2010

109. Which of the following is a classic systemic above-ground symptom of severe root nematode infection?
(A) Uniform gigantism of the stem
(B) Stunting and patchy field growth
(C) Rapid greening of old leaves
(D) Proliferation of flowers

2024

110. Above-ground chlorosis caused by root nematodes is primarily a secondary effect of:
(A) Direct nematode feeding on host chloroplasts
(B) Impaired water and mineral nutrient uptake
(C) Toxins translocated from the soil to leaves
(D) Viral vectors exclusively causing the yellowing

2010

111. The phenomenon where plants infected with root nematodes wilt during the hottest part of the day, even when soil moisture is adequate, is termed:
(A) Permanent wilting point reached in soil
(B) Midday wilting or temporary wilting
(C) Hydraulic failure of the xylem elements
(D) Apoplexy of the entire plant structure

2025

112. Crinkling, distortion, and necrosis of leaves are typical above-ground symptoms directly caused by:
(A) Root-knot nematodes within the soil
(B) Foliar nematodes like Aphelenchoides
(C) Cyst nematodes affecting the root system
(D) Lesion nematodes causing root necrosis

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molecules
(C) Cementing the stylet shut during feeding
(D) Blocking the nematode's respiratory pores

2024

179. A high baseline concentration of phenolic compounds in root endodermal cells serves to:
(A) Stimulate giant cell formation in roots
(B) Deter feeding and inhibit hydrolytic enzymes
(C) Attract male nematodes from the surrounding
(D) Enhance host susceptibility to the infection

2008

180. Why is constitutive resistance often considered more durable, though sometimes less effective, than induced major-gene resistance?
(A) It relies on complex and polygenic traits
(B) It relies on a single, easily mutable gene
(C) It only targets the male nematode in soil
(D) It works only in extremely dry soil types

2022

181. The hypersensitive response (HR) is a hallmark of which type of defense?
(A) Post-infectional structural defense
(B) Constitutive chemical defense
(C) Post-infectional biochemical/active defense
(D) Pre-infectional passive defense

2025

182. Consider the following statements regarding the hypersensitive response (HR) in nematode-plant interactions:
I. It is triggered by specific recognition of nematode effectors.
II. It involves rapid, localized programmed cell death.
III. It provides nutrients to the invading nematode.
IV. It starves biotrophic nematodes by destroying their potential feeding site.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) II, III and IV
(C) I, III and IV
(D) I, II and III

2024

183. Which cellular event is visually diagnostic of the hypersensitive response in root tissues?
(A) Rapid greening of the cells after infection
(B) Cytoplasmic streaming in the vascular cells
(C) Browning of cells surrounding the nematode
(D) Massive enlargement into a syncytium site

2025

184. How does the HR specifically defeat sedentary endoparasites like Meloidogyne?
(A) Necrosis prevents giant cell formation
(B) Dead cells produce huge amounts of sugar
(C) The HR kills the nematode via electrical shock
(D) The HR causes the root to detach from the plant

NODIA

2012

185. Post-infectional structural resistance can involve the formation of what structure around the nematode or its feeding site?
(A) A thick layer of cork or wound periderm
(B) A new apical meristem in the root zone
(C) A large drop of water at the infection site
(D) A secondary seed coat forming on the root

2017

186. Tyloses formation is a post-infectional mechanism primarily designed to:
(A) Block xylem vessels to prevent spread
(B) Provide a soft tissue for nematode feeding
(C) Increase water flow to the feeding site
(D) Facilitate nematode migration upward in plant

2017

187. Callose deposition in response to nematode stylet penetration serves to:
(A) Soften the cell wall for easier penetration
(B) Reinforce the cell wall and plug the puncture
(C) Act as a chemical attractant for the nematode
(D) Stimulate cell division in the cortex region

2025

188. Which cellular organelle plays a central role in orchestrating the programmed cell death during an HR?
(A) The Golgi apparatus within the host cell
(B) The mitochondrion via release of cytochrome c
(C) The smooth endoplasmic reticulum of the plant
(D) The amyloplast in the root cap cells

2006

189. In a resistant reaction against cyst nematodes, what typically happens to a nascent syncytium?
(A) It becomes heavily lignified and grows indefinitely
(B) It undergoes vacuolization and collapses
(C) It transforms into a giant cell during the stage

(C) Resistance prevents hypersensitivity from occurring
(D) They are mutually exclusive biological phenomena

2009

169. Select the correct sequence of plant defense barriers a nematode encounters.
(A) Constitutive chemical defenses → Pre-existing structural barriers → Induced structural defenses → Induced biochemical defenses
(B) Pre-existing structural barriers → Constitutive chemical defenses → Induced structural defenses → Induced biochemical defenses
(C) Induced biochemical defenses → Constitutive chemical defenses → Pre-existing structural barriers → Induced structural defenses
(D) Induced structural defenses → Pre-existing structural barriers → Induced biochemical defenses → Constitutive chemical defenses

2023

170. Constitutive resistance refers to defense mechanisms that:
(A) Are only activated after the nematode injects effectors
(B) Require the presence of a viral vector
(C) Are naturally present in the plant regardless of nematode presence
(D) Depend entirely on exogenous chemical applications

2004

171. Which of the following is a classic example of a pre-infectional (constitutive) structural barrier?
(A) Formation of an abscission layer in the root
(B) Thick, heavily suberized or lignified exodermis
(C) Production of a localized hypersensitive response
(D) Synthesis of phytoalexins after initial infection

2007

172. Nematodes attempting to penetrate roots with high constitutive levels of lignin often fail because:
(A) Lignin dissolves their cuticle instantly
(B) Lignin physically resists the stylet thrusts
(C) Lignin turns into a volatile toxic gas in soil
(D) Lignin attracts predatory fungi to the roots

2012

173. Pre-infectional chemical resistance involves naturally occurring plant compounds. Which of the following is an example?
(A) Alpha-tomatine in tomato roots
(B) PR-1 proteins synthesized after infection
(C) Reactive oxygen species burst
(D) De novo synthesized phytoalexins

2018

174. The root cap and mucilage can act as constitutive defenses by:
(A) Releasing highly toxic cyanide compounds in soil
(B) Physically trapping or repelling the nematodes
(C) Rapidly dividing to push the nematode away
(D) Actively dissolving the nematode stylet structure

2012

175. Some plants exude naturally occurring nematicidal compounds into the soil as a constitutive defense. Marigold (Tagetes spp.) is famous for exuding:
(A) Gossypol
(B) Alpha-terthienyl
(C) Solanine
(D) Phaseolin

2015

176. Which structural feature at the cellular level provides constitutive resistance against intercellular migration?
(A) Thin primary cell walls in the root cortex
(B) High calcium pectate in the middle lamella
(C) Large central vacuoles within the host cells
(D) Abundance of plasmodesmata between the cells

2012

177. The presence of dense root hairs can influence nematode infection by:
(A) Acting as a physical impediment to nematodes
(B) Providing the primary feeding site for species
(C) Acting as conduits directly into the xylem vessels
(D) Increasing the soil temperature locally in soil

2012

178. Saponins present constitutively in some plant roots act defensively by:
(A) Disrupting nematode cell membranes on contact
(B) Binding to nematode DNA and RNA

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2002

199. When a nematode population is exposed to a host with a single major R gene over several seasons, the most likely evolutionary outcome is:
(A) THE plant will lose its R gene in soil
(B) THE nematode population will go extinct
(C) Selection for nematodes lacking the Avr gene
(D) THE nematodes will evolve to eat the leaves

2007

200. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Gene-for-gene resistance often results in a hypersensitive response (HR).
Reason (R): HR is the universal baseline defense in all plants regardless of R gene presence.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

201. Which term describe a nematode effector that is recognized by an R gene?
(A) Virulence factor
(B) Avirulence (Avr) protein
(C) Elicitin
(D) Susceptibility target

2010

202. Effector-Triggered Immunity (ETI) in plant-nematode interactions is primarily synonymous with:
(A) Constitutive resistance
(B) Basal resistance (PTI)
(C) R gene-mediated resistance
(D) Tolerance

2022

203. PAMP-Triggered Immunity (PTI) differs from ETI (R gene resistance) in that PTI is triggered by:
(A) Highly specific and rapidly mutating effectors
(B) Conserved signatures like cuticular components
(C) Only viral coat proteins found in the plant
(D) Environmental stress factors and soil conditions

NODIA

2007

204. Why do nematodes secrete effectors that suppress PTI?
(A) To trigger the hypersensitive response in roots
(B) To prevent basal defense from halting infection
(C) To kill surrounding soil bacteria in the field
(D) To increase lignin deposition in cell walls

2016

205. THE Mi-1 gene, the first cloned nematode resistance gene, was discovered in which plant?
(A) Solanum tuberosum (Potato)
(B) Beta vulgaris (Sugar beet)
(C) Solanum peruvianum (Wild tomato)
(D) Glycine max (Soybean)

2019

206. THE Mi-1.2 gene confers resistance to several species of Meloidogyne and remarkably also to which insect pest?
(A) Potato aphid found in agricultural fields
(B) Whitefly species inhabiting tropical crops
(C) Colorado potato beetle affecting tuber yield
(D) Both potato aphid and specific whiteflies

2025

207. A notable limitation of the resistance conferred by the Mi-1 gene in tomato is that it:
(A) Only works in hydroponic systems
(B) Is purely recessive
(C) Fails at soil temperatures above 28°C
(D) Causes the tomato fruit to be toxic

2015

208. Match the cloned R-gene (List I) with its primary target nematode (List II).
List I: Cloned R-gene
P. Mi-1
Q. Hs1pro-1
R. Gpa2
S. Hero
List II: Target Nematode
1. Globodera pallida
2. Globodera rostochiensis
3. Heterodera schachtii
4. Meloidogyne spp.
(A) P-4, Q-3, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-2, R-3, S-4

2024

209. THE Hs1pro-1 gene confers resistance in sugar beet against which nematode?

(D) Chlorine

2017

233. THE concept of "sink competition" in nematode-infected plants refers to:
(A) Roots competing with soil microbes for space
(B) Feeding sites acting as strong metabolic sinks
(C) THE nematode competing with fungi for oxygen
(D) Leaves sinking under the weight of water

2002

234. Consider the following statements regarding host physiological alterations:
I. Transpiration rates often decrease due to stomatal closure.
II. Nematode feeding sites accumulate high concentrations of imported sucrose.
III. Xylem disruption leads to reduced shoot water potential.
IV. Photosynthetic efficiency is typically enhanced to compensate for damage.
V. Nutrient translocation from roots to shoots is impaired.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, IV and V

2024

235. To sustain high metabolic activity, feeding cells like syncytia upregulate the expression of:
(A) Genes for lignin synthesis in the root
(B) Sucrose transporters and amino acid permeases
(C) Photosynthetic genes such as RuBisCO in leaf
(D) Viral coat proteins within the host plant

2010

236. Changes in the carbon-to-nitrogen (C:N) ratio of the host plant due to nematode infection typically result in:
(A) Improved fruit quality in the host plant
(B) Altered susceptibility to secondary pathogens
(C) Immediate death of the apical meristem zone
(D) Increased frost resistance in the greenhouse

2019

237. Nematode infection often alters the partitioning of biomass in the plant, generally resulting in:
(A) A higher shoot-to-root ratio in the plant
(B) A lower shoot-to-root ratio in the host
(C) Equal biomass distribution regardless of damage
(D) Total absence of root biomass after infection

2007

238. Invertase enzymes are often found upregulated in giant cells. Their primary physiological role there is to:
(A) Build cellulose within the host cell wall
(B) Cleave imported sucrose into glucose and fructose
(C) Export starch to the leaves from the roots
(D) Synthesize lipids for the nematode egg mass

2021

239. Premature leaf senescence in nematode-infected plants is hormonally linked to an increase in:
(A) Auxin
(B) Cytokinin
(C) Ethylene and Abscisic acid (ABA)
(D) Gibberellins

2005

240. THE localized increase in osmotic pressure within a feeding site is essential because it:
(A) Kills the nematode within the feeding cell
(B) Drives the influx of water and nutrients
(C) Shrinks the giant cell during the development
(D) Solidifies the cell wall of the feeding site

2019

241. THE formation of root galls by Meloidogyne requires the localized accumulation of which plant hormone?
(A) Auxin (IAA)
(B) Salicylic acid
(C) Jasmonic acid
(D) Brassinosteroids

2001

242. How do root-knot nematodes manipulate auxin gradients within the root?
(A) By directly secreting large quantities of pure IAA
(B) By altering plant PIN efflux carrier proteins
(C) By completely destroying all auxin in the plant
(D) By turning auxin into ethylene within cells

2002

243. High levels of cytokinins are required during the early stages of giant cell formation to:
(A) Trigger rapid cell death in the host plant
(B) Stimulate the cell cycle and acytokinetic mitosis

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I. Inoculate with a known initial population (Pi).
II. Extract and count the final nematode population (Pf).
III. Grow the plant for an appropriate duration (e.g., 60 days).
IV. Calculate the ratio $\frac{Pf}{Pi}$.

(A) I, II, III, IV
(B) I, III, II, IV
(C) III, I, II, IV
(D) I, IV, III, II

2018

222. If a pot was inoculated with 1,000 eggs (Π) and 60 days later 5,000 eggs were extracted (Pf), the Reproduction Factor (Rf) is:
(A) 0.2
(B) 5.0
(C) 4,000
(D) 6,000

2005

2001

223. An Oostenbrink Reproduction Factor (Rf) calculation is considered the most reliable indicator of:
(A) THE physical weight of the galls in roots
(B) THE actual host status of the tested plant
(C) THE toxicity of a chemical nematicide in soil
(D) THE size of the giant cells in the vascular

2023

224. Which index focuses on estimating the proportion of a root system covered by cysts?
(A) Gall index
(B) Cyst index
(C) Lesion index
(D) Necrosis scale

2002

225. In field screening, what environmental factor can severely skew Gall Index results and must be controlled or accounted for?
(A) Uneven distribution of nematodes in the soil
(B) Time of day the evaluation is made in field
(C) Atmospheric CO2 levels during the experiment
(D) Leaf color of the plants being evaluated

2009

226. When determining Π for a field experiment, soil sampling should ideally occur:
(A) Exactly at harvest time for the crop
(B) During the middle of the growing season
(C) Immediately before or at the time of planting
(D) One year prior to planting the host crop

2003

227. A Reproduction Factor ($\frac{Pf}{Pi}$) of 0 indicates that the plant is:
(A) Immune or extremely resistant host variety
(B) Highly susceptible plant in the trial
(C) Highly tolerant plant in the greenhouse
(D) Intolerant host plant in the agricultural field

2022

228. THE number of egg masses per root system is often stained for easier counting using which dye?
(A) Methylene blue
(B) Phloxine B
(C) Iodine
(D) Safranin

2021

229. Heavy infection by root-knot nematodes typically alters host plant water relations by:
(A) Dramatically increasing water use efficiency
(B) Decreasing conductivity and inducing stress
(C) Enhancing stomatal opening during a drought
(D) Forcing water out of the leaves via guttation

2024

230. THE reduction in root hydraulic conductivity in infected plants is primarily attributed to:
(A) Excess root hairs growing from the root
(B) Disruption of xylem around feeding sites
(C) Increased aquaporin synthesis in the roots
(D) THE nematode drinking all the available water

2017

231. How does nematode infection typically affect the rate of photosynthesis in the host plant?
(A) IT significantly increases to feed the nematode
(B) IT remains completely unchanged in the plant
(C) Reduction due to stomatal closure and chlorophyll
(D) IT shifts from C3 to C4 metabolism in leaves

2010

232. Mineral nutrient uptake in nematode-infected roots is generally impaired. Which macronutrient deficiency is most frequently visually manifested?
(A) Nitrogen
(B) Calcium
(C) Sulfur

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2014

254. Glyceollin is a well-known phytoalexin produced in response to nematode infection in which crop?
(A) Potato
(B) Cotton
(C) Soybean
(D) Tomato

2006

255. Gossypol, which accumulates in specialized glands and acts against nematodes, is primarily associated with:
(A) Soybean
(B) Wheat
(C) Cotton
(D) Sugar beet

2022

256. THE rapid accumulation of phenolic compounds in cells adjacent to a migrating nematode is a defensive strategy because phenolics:
(A) Are highly nutritious for the plant tissues
(B) Act as precursors and oxidize into toxic quinones
(C) Make the root slippery to prevent the infection
(D) Turn into water within the host root cytoplasm

2018

257. Pathogenesis-related (PR) proteins are typically produced by the plant:
(A) Systemically during normal healthy plant growth
(B) In large quantities following pathogen recognition
(C) Only in the seeds of the infected host variety
(D) By the chloroplasts during photosynthesis cycles

2008

258. Which specific class of Pathogenesis-Related (PR) proteins degrades the structural polymers of fungal cell walls and is upregulated during nematode infection?
(A) PR-1 proteins
(B) Chitinases (PR-3)
(C) Lipid transfer proteins (PR-14)
(D) Defensins (PR-12)

2008

259. What role do proteinase inhibitors (PIs) play in plant defense against nematodes?
(A) They digest the nematode's cuticle directly
(B) They inhibit digestive proteases of the nematode
(C) They inhibit plant photosynthesis in the leaves
(D) They destroy plant DNA within the host cells

2021

260. Match the biochemical defense component (List I) with its function (List II).
List I: Biochemical Defense Component
P. Phytoalexin (e.g., Glyceollin)
Q. Proteinase Inhibitors
R. Phenolics
S. Callose
List II: Function
1. Physical plugging of penetration sites
2. De novo synthesized toxic antimicrobial compound
3. Inactivation of nematode digestive enzymes
4. Precursors for toxic quinones and lignin
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-1, Q-4, R-3, S-2

NODIA

2019

261. THE systemic signaling molecule that moves from infected tissues to uninfected parts of the plant to establish Systemic Acquired Resistance (SAR) is largely derived from:
(A) Jasmonic Acid
(B) Salicylic Acid
(C) Auxin
(D) Ethylene

2001

262. Nematode feeding sites in susceptible plants often show a marked decrease in the expression of defense-related genes. This phenomenon is known as:
(A) Effector-triggered immunity in plant
(B) Active suppression of host defense
(C) Hypersensitivity in the root tissues
(D) Autoimmunity within the host cells

2016

263. Flavonoids, a class of secondary metabolites, can influence nematode infection by acting as:
(A) Direct inhibitors of the stylet muscles
(B) Modulators of auxin transport and movement
(C) Building blocks for nematode DNA molecules
(D) Primary sources of nitrogen for the nematode

2012

264. In resistant roots exhibiting an HR, the rapid browning is primarily the visible result of:
(A) Chlorophyll breakdown in cells

(C) Cause the root to stop growing completely in soil
(D) Induce leaf abscission in the aerial tissues

2004

244. Nematodes have been shown to secrete molecules that mimic which plant hormone to promote cell division?
(A) Abscisic acid
(B) Cytokinin
(C) Gibberellic acid
(D) Salicylic acid

2014

245. Ethylene production is often upregulated during nematode penetration and infection. What role does it primarily play?
(A) IT stimulates the formation of a thickened cuticle
(B) IT promotes tissue softening and radial expansion
(C) IT turns off all resistance genes in the plant
(D) IT causes the nematode eggs to hatch immediately

2008

246. THE balance between which two hormones is critical for the induction and maintenance of feeding cells?
(A) Salicylic acid and Jasmonic acid
(B) Auxin and Cytokinin
(C) Ethylene and Abscisic acid
(D) Gibberellin and Brassinosteroid

2012

247. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Root-knot nematodes can manipulate host developmental pathways by secreting CLE-like peptides.
Reason (R): These peptides mimic endogenous plant CLE peptides that normally regulate meristem maintenance via receptor kinases.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

248. Disruption of auxin transport in a root using chemical inhibitors like NPA (1-N-naphthylphthalamic acid) typically results in:
(A) Giant cells growing twice as large in the root
(B) Failure of gall formation and development
(C) Rapid multiplication of nematodes in the soil
(D) Transformation of roots into stems in the plant

2023

249. Which hormone pathway is classically associated with systemic defense signaling against biotrophic pathogens, including some stages of sedentary nematodes?
(A) Salicylic acid (SA)
(B) Gibberellic acid (GA)
(C) Strigolactones
(D) Auxin

2007

250. Jasmonic acid (JA) signaling is primarily involved in plant defense against:
(A) Viruses in the plant
(B) Necrotrophic pathogens and chewing insects
(C) Frost damage in the field
(D) UV radiation in the greenhouse

2010

251. How does the nematode effector repertoire interact with host salicylic acid (SA) pathways during a compatible interaction?
(A) They strongly upregulate SA to create a feeding site
(B) They suppress SA to prevent defense activation
(C) They convert SA into auxin within the host cells
(D) They use SA as a primary carbon source for growth

2008

252. THE localized swelling seen in root knots is a combination of cell hyper-division and expansion, driven fundamentally by:
(A) High levels of abscisic acid in the root
(B) Localized accumulation of auxin and ethylene
(C) Complete absence of all hormones in the site
(D) Excess gibberellin from the soil environment

2023

253. Phytoalexins are defined as:
(A) Pre-existing defensive chemicals in plant
(B) Antimicrobial compounds synthesized de novo
(C) Toxins produced by the nematode structure
(D) Synthetic nematicides used in management

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cycle

2002

276. THE localized accumulation of ROS at the site of nematode penetration can often be visualized in the laboratory using which stain?
(A) DAB (3,3'-diaminobenzidine)
(B) Toluidine blue
(C) Acid fuchsin
(D) Methylene blue

2015

277. Molecular mimicry in plant-parasitic nematodes refers to the evolutionary strategy where nematodes:
(A) Physically look like plant roots in soil
(B) Secretion of proteins similar to host proteins
(C) Mimic behavior of beneficial soil bacteria
(D) Alter their DNA to match the host perfectly

2005

278. Nematode-secreted CLE-like peptides are famous examples of molecular mimicry. In the plant, natural CLE peptides regulate:
(A) Photosynthesis rates
(B) Stem cell maintenance and differentiation in meristems
(C) Stomatal aperture
(D) Seed dormancy

2022

279. By secreting CLE-like peptides into the root, cyst nematodes are able to:
(A) Immediately kill the root after penetration
(B) Hijack plant signaling to promote syncytia
(C) Stop all root growth globally in the host plant
(D) Attract male nematodes from long distances in soil

2023

280. Which nematode effector mimics a plant cellular component to modulate the host cell cycle and prevent normal cytokinesis?
(A) Secreted cellulases
(B) Secreted expansins
(C) Secreted cyclins or cyclin-like proteins
(D) Secreted lipases

2024

281. Expansins are plant proteins that loosen cell walls. Nematodes have evolved to secrete expansin-like proteins (molecular mimicry) to:
(A) Expand their own cuticle during the molts
(B) Facilitate penetration and expansion of cells
(C) Make the plant grow taller in the field zone
(D) Shrink the host cell vacuole in the feeding site

2014

282. THE evolutionary acquisition of plant-like genes (such as CWDEs) by nematodes is widely hypothesized to have occurred via:
(A) Convergent point mutations in soil
(B) Horizontal gene transfer from bacteria or fungi
(C) Direct mating with plants in the environment
(D) Viral infections from insects in the greenhouse

2005

283. Some nematodes secrete chorismate mutase, an enzyme usually found in plants. Its function in mimicry/manipulation is to:
(A) Alter the plant's pathway to reduce defenses
(B) Directly synthesize giant cell walls in roots
(C) Increase starch production in the feeding site
(D) Digest the middle lamella during tissue entry

2007

284. Nematode effectors that mimic plant transcription factors are designed to:
(A) Transcribe nematode DNA faster in the cell
(B) Directly reprogram host gene expression
(C) Destroy host ribosomes in the host cytoplasm
(D) Exit the plant and signal other nematodes in soil

2021

285. A nematode effector containing a nuclear localization signal (NLS) is destined to act within the host's:
(A) Mitochondrion
(B) Vacuole
(C) Nucleus
(D) Endoplasmic reticulum

NODIA

2007

286. Consider the following statements regarding molecular mimicry:
I. IT involves the secretion of proteins structurally similar to host proteins.
II. CLE-like peptides are an example of molecular mimicry.
III. IT always results in the immediate death of the host cell.
IV. IT allows nematodes to hijack endogenous host signaling pathways.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) I and IV

(B) Starch accumulation in the root
(C) PPO oxidizing phenolics into quinones
(D) Cyanide gas release in the cytoplasm

2017

265. THE "oxidative burst" in a plant defense response refers to:
(A) Rapid uptake of oxygen for normal respiration
(B) THE sudden and massive production of Reactive Oxygen Species (ROS)
(C) THE explosion of root cells due to water pressure
(D) THE release of carbon dioxide during fermentation

2004

266. Which of the following is a primary Reactive Oxygen Species (ROS) involved in plant defense?
(A) Hydrogen peroxide (H2O2)
(B) Nitrogen gas (N2)
(C) Methane (CH4)
(D) Ammonia (NH3)

2013

267. What dual role does hydrogen peroxide (H2O2) play during a resistance response?
(A) IT acts as a fertilizer and a growth hormone
(B) IT acts as a toxin and signaling molecule
(C) IT dissolves lignin and softens the cell wall
(D) IT provides water for the nematode in the root

2013

268. Which enzyme is primarily responsible for the rapid generation of superoxide radicals during the oxidative burst?
(A) RuBisCO
(B) NADPH oxidase (RBOH)
(C) ATP synthase
(D) Amylase

2014

269. THE enzyme Peroxidase plays a critical role in host defense by:
(A) Producing massive amounts of auxin in plant
(B) Utilizing H2O2 to catalyze cell wall cross-linking
(C) Digesting the nematode stylet during feeding
(D) Converting nitrate to nitrite in host roots

2010

270. Polyphenol oxidase (PPO) contributes to resistance by:
(A) Oxidizing phenolic compounds into toxic quinones
(B) Reducing quinones back to phenolics in cells
(C) Producing huge amounts of sugar in the site
(D) Destroying host ribosomes in the cytoplasm

2001

271. Phenylalanine ammonia-lyase (PAL) is a crucial regulatory enzyme because it controls the entry point into which major metabolic pathway?
(A) Glycolysis pathway
(B) THE Krebs Cycle
(C) THE phenylpropanoid pathway for phenolics
(D) THE lipid biosynthesis pathway in plants

2023

272. Upregulation of PAL activity following nematode infection is strongly indicative of:
(A) A highly susceptible response in the root
(B) THE activation of biochemical defense mechanisms
(C) Nematode starvation occurring in the plant
(D) Plant senescence in the agricultural field

2012

273. Consider the following enzymes:
I. Peroxidase
II. Polyphenol oxidase (PPO)
III. Phenylalanine ammonia-lyase (PAL)
Which of the above are critical to the biochemical defense response against nematodes?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2012

274. To protect themselves from the toxic effects of the plant's oxidative burst, successful nematodes secrete:
(A) Massive amounts of ROS into the host cell
(B) ROS-scavenging enzymes such as peroxiredoxins
(C) Acidic compounds to neutralize the plant cells
(D) Hardened cuticular scales on the nematode body

2014

275. Superoxide dismutase (SOD) acts by catalyzing the conversion of:
(A) Water into hydrogen peroxide in the host cell
(B) Superoxide radicals into peroxide and oxygen
(C) Hydrogen peroxide into water and oxygen in root
(D) Lignin into phenolics during the defense

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(C) Measuring the speed of nematode movement in soil
(D) Counting the number of eggs produced in the mass

2017

298. In a resistant response, transcriptomic data often shows the rapid activation of WRKY genes. WRKYs are:
(A) Structural proteins in the host cell wall
(B) Plant transcription factors regulating defense
(C) Nematode enzymes that degrade cell wall layers
(D) Reactive oxygen species found in the cytoplasm

NODIA

2013

299. Consider the following statements regarding omics shifts during nematode infection:
I. Susceptible interactions show upregulation of defense genes forever.
II. Resistant interactions are characterized by rapid HR-related transcripts.
III. Dual RNA-seq profiles both host and parasite simultaneously.
IV. Giant cells show downregulated metabolic pathways.
V. THE secretome consists of proteins delivered by the nematode.
Which of the above statement(s) is/are correct?
(A) II, III and V
(B) I, III and IV
(C) II, IV and V
(D) I, II and V

2015

300. THE ultimate goal of comparative omics (transcriptomics, proteomics, genomics) in studying susceptible versus resistant nematode-plant interactions is to:
(A) Prove that nematodes are actually fungi
(B) Eradicate all soil microorganisms in fields
(C) Identify molecular targets for resistant crops
(D) Increase the visual appeal of root galls

****

(D) III

2018

287. Nematode secretions sometimes contain mimics of plant defense suppressors, functioning to:
(A) Trigger a massive HR in roots
(B) Keep the plant's immune system repressed
(C) Warn neighboring plants of the infection
(D) Stimulate jasmonic acid production in leaves

2018

288. THE presence of functional mimicry effectors provides a strong argument that sedentary nematodes act as:
(A) Simple mechanical destructive agents
(B) Sophisticated biotrophic engineers of host tissue
(C) Necrotrophs that thrive on dead tissue
(D) Incidental saprophytes

2016

289. Transcriptomic studies of compatible nematode-plant interactions (susceptible hosts) typically reveal a massive upregulation of genes involved in:
(A) Programmed cell death in roots
(B) Cellular metabolism and transport genes
(C) Cuticle degradation in the nematode
(D) Systemic acquired resistance in plant

2021

290. In contrast, transcriptomic profiling of an incompatible (resistant) interaction during the early hours of infection shows rapid upregulation of:
(A) Sucrose transporter genes in cells
(B) Defense-related genes like PR and WRKY
(C) Cell cycle genes like cyclins in root
(D) Expansin genes in host tissues

2022

291. Genomic shifts in a nematode population exposed repeatedly to a resistant cultivar are most likely to show:
(A) Random genome-wide duplications in soil
(B) Selection for mutations in effector genes
(C) Complete loss of the mitochondrial genome
(D) Loss of all cell wall degrading enzymes in body

2012

292. Proteomic analysis of giant cells compared to normal root cells indicates a significant increase in proteins associated with:
(A) Photosynthesis and light harvesting in roots
(B) Protein synthesis and metabolic turnover
(C) Lignin biosynthesis exclusively in the site
(D) Starch degradation into structural cellulose

2017

293. Small RNAs (sRNAs), including microRNAs (miRNAs), have been shown to shift dynamically during infection. Their primary role is:
(A) To act as structural components of the cell wall
(B) Post-transcriptional regulation of gene expression
(C) To provide a direct energy source for host cells
(D) To serve as physical channels for nutrient uptake

2005

294. Dual RNA-seq is a powerful omics technology used in nematology to simultaneously analyze:
(A) THE DNA of the nematode and the soil bacteria
(B) THE transcriptomes of both host and parasite
(C) Only the small RNAs of the host variety tested
(D) THE proteome and the metabolome of the plant tissues

2023

295. Metabolomic profiling of roots infected by root-knot nematodes typically reveals a localized accumulation of:
(A) Highly toxic heavy metals in the soil
(B) Sugars, amino acids, and organic acids
(C) Chlorophyll in the host root tissues
(D) Suberin precursors only in the cell wall

2011

296. Epigenetic shifts, such as changes in DNA methylation in the host plant genome during nematode infection, are responsible for:
(A) Changing the DNA sequence permanently in root
(B) Transcriptional reprogramming for the feeding site
(C) Immediate mechanical strengthening of the cell wall
(D) Digesting the nematode stylet during the feeding

2011

297. Proteomic analysis of nematode secretions (the secretome) has been crucial for:
(A) Discovering new cuticular structures on body
(B) Identifying the effector proteins injected

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(A) Heterodera glycines
(B) Heterodera avenae
(C) Heterodera schachtii
(D) Globodera pallida

2017

210. Which class of protein does the Hs1pro-1 gene encode?
(A) A standard NBS-LRR protein in the plant
(B) Transmembrane protein with extracellular LRR
(C) A basic leucine zipper (bZIP) transcription factor
(D) A protease inhibitor produced by the host

2014

211. THE Gpa2 gene from potato confers resistance against which specific nematode?
(A) Globodera rostochiensis
(B) Globodera pallida
(C) Meloidogyne chitwoodi
(D) Pratylenchus penetrans

2019

212. Interestingly, the Gpa2 gene in potato shares high sequence homology with Rx1, a gene that provides resistance against:
(A) Potato Virus Y (PVY)
(B) Potato Virus X (PVX)
(C) Phytophthora infestans
(D) Erwinia carotovora

2017

213. THE Hero A gene, cloned from tomato, confers broad-spectrum resistance against:
(A) All Meloidogyne species found in the soil
(B) Both Globodera rostochiensis and G. pallida
(C) Radopholus similis found in tropical roots
(D) Xiphinema index populations in the vineyard

2016

214. Gro1-4 is a resistance gene derived from Solanum spegazzinii that targets:
(A) Globodera rostochiensis
(B) Heterodera glycines
(C) Meloidogyne incognita
(D) Aphelenchoides besseyi

2014

215. THE Rhg1 (Resistance to Heterodera glycines) locus in soybean is unusual among R-genes because resistance is mediated by:
(A) A single dominant NBS-LRR gene in soybean
(B) Copy number variation of a block of three genes
(C) A single recessive loss-of-function mutation
(D) Viral integration into the soybean genome

2013

216. Which transgenic approach mimics natural R-gene resistance by specifically degrading essential nematode mRNA?
(A) Expression of Bt toxins within the plant
(B) Host-Induced Gene Silencing via RNAi
(C) Overexpression of cellulase in root tissues
(D) Application of CRISPR-Cas9 to the soil matrix

2024

217. THE Gall Index is a widely used screening tool primarily designed for assessing damage caused by:
(A) Cyst nematodes
(B) Lesion nematodes
(C) Root-knot nematodes
(D) Stem nematodes

2004

218. In the standard 0 to 5 Gall Index scale, a rating of 0 indicates:
(A) No galls are present
(B) Only 5 galls are present
(C) 100% of the root system is galled
(D) THE plant is dead

2001

219. According to a common 0-5 scale, a root system with 50% of its roots galled would most likely receive a score of:
(A) 1
(B) 2
(C) 3
(D) 5

2015

220. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): THE Gall Index alone perfectly measures the reproduction rate of Meloidogyne.
Reason (R): Some plants may form large galls without supporting successful egg production.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2007

221. Determine the correct sequence for assessing the Reproduction Factor ($\frac{Pf}{Pi}$) in a greenhouse trial.

ANSWERS

1. (A) Evolution from fungivorous ancestors within the soil ecosystem
Plant-parasitic nematodes likely evolved from soil-dwelling fungivorous ancestors. This transition involved developing specialized mouthparts like the stylet to pierce cell walls. Evolutionary paths are supported by phylogenetic analyses showing close relationships between fungal feeders and plant parasites. These ancestors possessed the metabolic machinery required to navigate soil environments and utilize complex nutrients found in plant cells.

2. (C) Acquisition of a protrusible stylet
The transition to plant parasitism necessitated a specialized structure for cell wall penetration. A protrusible stylet, whether a stomatostylet or odontostylet, serves as a hollow needle for injecting enzymes and withdrawing nutrients. This adaptation distinguishes plant parasites from free-living forms. It provides the mechanical force needed to breach tough cellulose barriers while maintaining the integrity of the nematode.

3. (A) Transition from consuming soil bacteria to plant cells
Adapting to plant roots required a fundamental shift in feeding targets within the soil ecosystem. Nematodes evolved from consuming simple soil bacteria to targeting the nutrient-rich cytoplasm of plant cells. This shift facilitated a more stable food supply and drove the development of complex host-parasite interactions. Such ecological transitions allowed for the exploitation of diverse niches within terrestrial environments.

4. (D) Presence of a stomatostylet or odontostylet
Diverse nematode lineages independently developed specialized feeding structures to exploit plant resources. The stomatostylet and odontostylet represent convergent evolutionary solutions for puncturing plant cell walls and facilitating nutrient ingestion. Despite different phylogenetic origins, these structures perform nearly identical biological functions. This convergence highlights the adaptive significance of the stylet for successful parasitism across various taxonomic groups of nematodes.

5. (B) Enlargement of oesophageal glands for effector secretion
Adopting a sedentary lifestyle requires sophisticated manipulation of host physiology to maintain permanent feeding sites. Enlarged oesophageal glands are essential for producing and secreting diverse effector proteins into host cells. These effectors suppress plant defenses and reorganize cellular structures into nutrient sinks. This physiological change is strongly correlated with the loss of motility and the establishment of long-term parasitic relationships.

6. (C) Aphelenchida
Members of the order Aphelenchida exhibit a wide range of feeding behaviors, from fungal feeding to facultative and obligate plant parasitism. This diversity represents a clear evolutionary transition between free-living soil inhabitants and specialized plant parasites. Their morphological features and ecological versatility provide critical insights into how parasitism developed. They serve as a vital link for understanding nematode adaptation and specialization.

7. (D) Cellulases
Horizontal gene transfer from soil bacteria provided plant-parasitic nematodes with the genetic capacity to produce cell-wall-degrading enzymes. Cellulases are particularly important for softening and degrading the cellulose components of plant cell walls during penetration. This acquisition was a pivotal evolutionary event, allowing nematodes to bypass complex mechanical barriers. These enzymes are secreted via the stylet to facilitate migration and feeding.

8. (A) It provides a stable, nutrient-rich environment
Parasitism is an advanced ecological strategy because it grants nematodes access to the highly regulated and nutrient-dense interior of plant tissues. This environment offers protection from environmental fluctuations and ensures a consistent food supply for growth and reproduction. By exploiting the host's metabolic processes, nematodes can maximize their reproductive potential while minimizing the energy required for finding food.

NODIA

between cells more easily, a process known as intercellular migration. This enzyme reduces mechanical resistance.

65. (A) I, II and IV
Nematode effectors are delivered directly into host cells via the hollow stylet. Once inside, they can manipulate host gene expression and suppress defensive immune responses. While many effectors are produced in the oesophageal glands, they are not exclusively limited to the subventral glands; the dorsal gland is also a major source. These molecules are essential for successful parasitism.

66. (B) The oesophageal glands
The "feeding tube" is a specialized structure formed within the host cell cytoplasm by secretions from the nematode's oesophageal glands. After injection through the stylet, these secretions coagulate to form a tube that connects the stylet tip to the host cytoplasm. This structure acts as a filter and facilitates the efficient withdrawal of nutrients while preventing host cell collapse.

67. (B) Host cell cycle regulators
Certain nematode effectors specifically target host cell cycle regulators to manipulate the developmental pathways of the plant. By interfering with normal cell division, these effectors can induce processes like endoreduplication and acytokinetic mitosis. This manipulation is essential for the formation of massive, multinucleate feeding cells like giant cells and syncytia, which provide a dedicated nutrient source for the parasite.

68. (B) The entire repertoire of secreted effector proteins from a parasite
The term "parasitome" refers to the complete set of proteins and other molecules secreted by a parasite into its host. In plant nematology, this primarily includes the suite of effector proteins produced in the oesophageal glands and delivered via the stylet. Understanding the parasitome is crucial for identifying how nematodes manipulate host biology and for developing targeted resistance strategies.

69. (B) Cell-wall degrading enzymes (CWDEs)
During the tissue migration phase, the subventral glands of infective juveniles are highly active and produce large quantities of cell-wall degrading enzymes. These include cellulases, pectate lyases, and hemicellulases. These enzymes are secreted to soften and break down the complex polysaccharides of the plant cell wall and middle lamella, allowing the nematode to move through the root tissue.

70. (B) By suppressing immune signaling and ROS production
To survive as biotrophs, nematodes must prevent the host plant from initiating a hypersensitive response, which would lead to localized cell death and starvation of the parasite. They achieve this by secreting specific effectors that suppress plant immune signaling and inhibit the production of reactive oxygen species. This active suppression allows the nematode to maintain a living feeding site.

71. (B) Alters the plant's shikimate pathway and defenses
Chorismate mutase is a nematode-secreted effector that acts on the plant's shikimate pathway. By diverting chorismate away from the synthesis of salicylic acid, a key defense signaling molecule, the nematode effectively reduces the host's ability to mount an immune response. This biochemical manipulation is a sophisticated strategy to ensure a compatible interaction and successful establishment of the parasite.

72. (C) Cytoplasm and eventually the host cell nucleus
Effectors injected by sedentary nematodes are primarily delivered into the host cell cytoplasm. From there, many travel to specific organelles, most importantly the nucleus. By entering the nucleus, these effectors can directly interact with host DNA and transcription factors to reprogram gene expression. This high-level manipulation is necessary for transforming normal root cells into specialized feeding structures.

73. (B) Being multinucleate due to acytokinetic mitosis
Giant cells, induced by root-knot nematodes, are characterized by being multinucleate. This state is achieved through acytokinetic mitosis, where the cell's nucleus divides repeatedly without subsequent division of the cytoplasm or the formation of new cell walls. This results in a single, massively enlarged cell containing dozens of nuclei, which supports the high metabolic activity needed by the nematode.

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18. (C) They are completely enveloped by host tissue throughout life
Semi-endoparasites are characterized by a feeding habit where only the head and neck regions are inserted into the host plant. The rest of the body remains outside the root surface. Therefore, the statement that they are completely enveloped by host tissue is incorrect. This unique arrangement allows them to access internal nutrients while depositing their eggs into the surrounding soil environment.

19. (A) Pratylenchus - Migratory endoparasite
Pratylenchus species are well-known migratory endoparasites that move through the root cortex, feeding on cells and causing necrotic lesions. This classification accurately reflects their mobile nature within the plant tissue. In contrast, Meloidogyne is a sedentary endoparasite, Trichodorus is a migratory ectoparasite, and Tylenchulus is a semi-endoparasite. Understanding these feeding habits is essential for diagnosing nematode damage and managing infestations.

20. (B) I and III
Ectoparasites often cause significant mechanical damage and root tip swelling, making the first statement incorrect. Similarly, semi-endoparasites can induce localized tissue changes and swelling at their feeding sites, making the third statement incorrect. In contrast, endoparasites do complete their life cycle inside the plant, and sedentary females typically lose their vermiform shape upon reaching maturity.

21. (B) Swollen, globose or pear-shaped body
Upon reaching maturity, female sedentary endoparasites undergo significant morphological changes to accommodate massive reproductive development. Their bodies swell and lose the typical slender, vermiform shape, becoming globose, pear-shaped, or lemon-shaped. This transformation is associated with the establishment of a permanent feeding site and the production of a large number of eggs. This specialized shape maximizes space for the reproductive system.

22. (C) Migratory ectoparasites
Nematodes that move across the root surface and feed on multiple epidermal cells without entering the tissue are classified as migratory ectoparasites. They use their stylets to puncture cells briefly before moving to a new location. This feeding strategy results in widespread but often superficial damage to the root system. Examples include members of the families Trichodoridae and Belonolaimidae.

23. (D) Continuous access to a sustained nutrient sink
The primary ecological advantage of the sedentary endoparasitic lifestyle is the establishment of a specialized feeding site that functions as a continuous nutrient sink. By manipulating host cell development, these nematodes ensure a steady supply of photosynthates and minerals directly from the plant's vascular system. This stable environment supports high reproductive rates and protects the parasite from external soil pressures.

24. (A) Globodera
Globodera, commonly known as the potato cyst nematode, is a prime example of a sedentary endoparasite. After entering the root as a juvenile, the female establishes a permanent feeding site called a syncytium and becomes immobile. As she matures, her body swells and eventually forms a protective cyst. Other genera like Belonolaimus and Helicotylenchus exhibit different feeding behaviors.

25. (B) Second-stage juvenile
In the life cycle of root-knot nematodes, the second-stage juvenile is the mobile, infective phase. After hatching from the egg, these juveniles migrate through the soil to locate and penetrate a suitable host root. Once inside, they move toward the vascular tissue to establish permanent feeding sites. Subsequent developmental stages occur within the root and involve the loss of motility.

26. (B) All juvenile stages and adults
Migratory endoparasites like Pratylenchus maintain their mobility throughout their entire life cycle. Consequently, all juvenile stages after hatching, as well as the adult males and females, are capable of leaving one root and infecting another. This flexibility allows the population to spread rapidly within a root system or through the soil to neighboring plants. This differs from sedentary species.

NODIA

46. (B) Retention of a vermiform shape throughout the life cycle
Unlike many sedentary root parasites, above-ground nematodes typically retain a slender, vermiform shape throughout all life stages. This morphology is an adaptation for movement through narrow spaces within plant tissues and swimming in thin films of water on plant surfaces. They remain mobile and can move between different parts of the host or even between plants during favorable conditions.

47. (B) Stem swelling, twisting, and distortion
Infection by stem nematodes of the genus Ditylenchus leads to characteristic physical symptoms including stem swelling, twisting, and overall distortion. This is caused by the breakdown of cell-to-cell adhesion in the parenchyma tissue as the nematodes feed and migrate. Macroscopically, these symptoms are often described as "tulip root" or "bloat," significantly affecting the structural integrity and growth of the host.

48. (B) It provides a supply of water and photosynthates
Sedentary nematodes target the root vascular tissue because it serves as the plant's primary transport system for nutrients and water. By establishing feeding sites like giant cells or syncytia in or near the xylem and phloem, the nematode gains direct access to a rich and continuous supply of energy. This allows the parasite to sustain its high metabolic demands.

49. (B) Stylet thrusting coupled with chemical degradation
Penetrating a host root cell wall is a dual process involving mechanical force and chemical action. The nematode uses rapid, coordinated stylet thrusts to physically puncture the wall. Simultaneously, it secretes a cocktail of hydrolytic enzymes from its oesophageal glands to soften and degrade the complex polysaccharides like cellulose and pectin. This combination allows for efficient entry into the host.

50. (A) P-3, Q-4, R-2, S-1
Subventral glands are active during initial tissue penetration, while the dorsal gland is primarily involved in maintaining the feeding site. The stylet is the physical tool used for puncturing cell walls. Amphids are specialized sensory organs used for detecting chemical cues like root exudates. This specialized anatomy allows the nematode to locate, enter, and feed on its host.

51. (C) Mechanical destruction of cells along the path
When infective juveniles migrate intracellularly through root tissue, they physically move from one cell to the next by puncturing the walls and membranes. This process inevitably causes the death and mechanical destruction of the cells along the nematode's path. Such damage can lead to visible browning and necrotic lesions, providing entry points for secondary soil-borne pathogens and fungi.

52. (B) I, III, II, IV
The infection process begins with the juvenile migrating toward the root tip following chemical gradients. It then penetrates the epidermal cells in the zone behind the root cap. Once inside, the nematode moves intercellularly through the cortex toward the vascular cylinder. Finally, it selects a specific provascular cell to initiate the formation of its permanent feeding site.

53. (A) Hydrostatic pressure of the pseudocoelom
Nematodes rely on the high hydrostatic pressure within their pseudocoelom to provide the mechanical leverage and structural rigidity needed for stylet thrusting. This internal pressure acts against the body wall, allowing the stylet muscles to contract effectively and drive the stylet forward into the tough plant cell wall. Without this pressure, the nematode would lack the force necessary for penetration.

54. (C) Intracellularly, causing significant cellular damage
Infective juveniles of cyst nematodes, such as Heterodera species, typically migrate through the root cortex in an intracellular manner. They use their stylets to cut through cell walls as they move directly from one cell to another. This destructive migration causes significant damage to the cortical tissue, leading to cell death and the formation of necrotic pathways toward the vascular.

55. (B) It provides support for stylet muscle contraction
The cephalic framework is a specialized, sclerotized structure in the head region of the nematode. It serves as a rigid internal anchor for the muscles that control the movement of

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soil-borne pathogens and predators. It creates a micro-environment that supports the successful development of the first-stage juveniles until they are ready to hatch.

37. (A) Aphelenchoides
The genus Aphelenchoides includes species commonly known as foliar nematodes, which primarily parasitize the above-ground parts of plants. They migrate through thin films of water on stems and leaves to enter through stomata. Once inside, they feed on the mesophyll cells, causing characteristic angular leaf spots and necrosis. This lifestyle differs significantly from typical soil-dwelling, root-parasitic nematodes.

38. (D) The apical meristem of the seedling
After emerging from seed galls in the soil, juveniles of the seed gall nematode, Anguina tritici, migrate upward through a film of water on the growing wheat plant. They target the apical meristem of the seedling, where they remain as ectoparasites for several weeks. As the plant transitions to flowering, they enter the developing floral tissues to induce gall formation.

39. (A) P-3, Q-4, R-1, S-2
Ditylenchus dipsaci targets stems and bulbs, causing distortion and necrosis. Aphelenchoides ritzemabosi is a foliar parasite affecting leaf tissues. Radopholus similis is a migratory endoparasite that lives within root tissues, while Heterodera avenae is a sedentary cyst nematode found on roots. Correctly identifying the primary site of parasitism for each genus is fundamental for diagnosing and managing infestations.

40. (A) Both A and R are true and R is the correct explanation of A
Foliar nematodes like Aphelenchoides are highly dependent on external moisture for survival and movement. They require a thin film of water on the plant surface to swim toward natural openings like stomata or wounds for infection. Because they lack the mechanical strength to pierce the dry, waxy cuticle of many plant organs, this reliance on water is absolute.

41. (A) Dissemination through contaminated seeds
The transmission of seed gall nematodes, such as Anguina tritici, occurs primarily through the distribution and planting of contaminated seed lots. The nematodes survive for long periods within the hardened galls that replace normal grain. When these galls are planted along with healthy seeds, the juveniles emerge in moist soil to infect new seedlings. This differs from root parasites.

42. (B) Extreme anhydrobiosis
Above-ground nematodes frequently encounter severe desiccation and temperature fluctuations on plant surfaces. To survive these conditions without a host, many species have evolved the ability to enter a state of extreme anhydrobiosis. In this state, their metabolism nearly stops, and they become highly resistant to environmental stress. This allows them to remain viable for years until favorable moisture returns.

43. (C) Bulbs and stems
Ditylenchus dipsaci, the stem and bulb nematode, is well-known for causing severe damage to bulbs and stems in many plant species. Its feeding activity causes the breakdown of the middle lamella between cells, leading to characteristic symptoms like “tulip root” in cereals and rot in onion bulbs. This nematode remains migratory throughout its life cycle, moving through the plant tissues.

NODIA

44. (B) Entry through natural openings such as stomata
Foliar nematodes belonging to the genus Aphelenchoides typically enter the leaf tissue through natural openings such as stomata. They migrate toward these openings through thin films of water on the leaf surface. Once inside the leaf, they feed on the mesophyll cells. This route of entry is a key characteristic of their parasitic strategy in above-ground tissues.

45. (B) Complex pore space, moisture, and root exudate gradients
Below-ground nematodes must navigate a highly complex and heterogeneous environment consisting of soil particles, water-filled pores, and air spaces. They rely on chemical gradients of root exudates to locate host roots. This environment provides relatively stable temperatures but presents physical challenges to movement and oxygen availability. Understanding these soil dynamics is crucial for predicting nematode behavior and management.

9. (B) Ectoparasitism
Ectoparasitism is considered the most primitive feeding strategy among plant-parasitic nematodes because it requires minimal internal modification of host tissues. Ectoparasites feed from the outside using their stylets to puncture epidermal or cortical cells without entering the root. This behavior mimics the grazing patterns of ancestral soil-dwelling nematodes. It lacks the complex cellular manipulation seen in more advanced endoparasitic strategies.

10. (C) I and III
Evolutionary progression toward sedentary parasitism began with primitive behaviors like grazing on root hairs and making transient punctures in cortical cells. These activities required mechanical penetration but lacked the sophisticated physiological manipulation needed for permanent feeding sites. Such transient interactions represent the initial stages of adaptation to plant hosts. Over time, these behaviors evolved into more specialized and permanent forms of parasitism.

11. (A) Co-evolution with plant defense mechanisms
The evolution of host specificity is primarily driven by the ongoing co-evolutionary struggle between nematodes and plant immunity. As plants developed specific defense mechanisms to recognize and halt infections, nematodes evolved specialized effectors to overcome these barriers. This reciprocal selection pressure leads to highly specific interactions between certain nematode populations and their corresponding host plants. Such specialization maximizes parasitic success.

12. (C) Penetration of the host cell wall
In early-stage juveniles, highly developed subventral glands are specialized for the production of cell-wall-degrading enzymes. These enzymes, including cellulases and pectate lyases, are essential for the mechanical and chemical penetration of host tissues during the initial infection phase. The activity of these glands is critical for successful entry into the root. They facilitate the breakdown of complex plant polymers.

13. (D) It feeds externally on the root using its stylet
Ectoparasitic plant nematodes reside entirely outside the host tissue throughout their life cycle. They use a specialized mouthpart called a stylet to pierce the surface cells of the root to extract nutrients. This feeding method does not involve the nematode body entering the plant. Such parasites are often mobile and can move between different feeding sites on the root system.

14. (C) Tylenchulus
The genus Tylenchulus represents the semi-endoparasitic feeding habit, where the anterior portion of the female body is embedded within the root while the posterior remains outside. This strategy allows the nematode to establish a permanent feeding site in the deeper cortical layers. The exposed posterior facilitates egg deposition into the soil or a gelatinous matrix. This specialized lifestyle balances protection and reproduction.

15. (B) They remain mobile and destroy cells as they feed
Migratory endoparasites are distinguished by their ability to maintain mobility within the host tissue throughout their life cycle. Unlike sedentary endoparasites, they do not establish a permanent feeding site. Instead, they move through the root cortex, feeding on and destroying numerous cells along their path. This constant movement leads to extensive necrotic lesions and significant mechanical damage to the root system.

16. (D) Radopholus
Radopholus is a classic example of a migratory endoparasite that spends its entire life cycle within the host root tissue. Both juveniles and adults are highly mobile, moving through the cortex to feed on various cells. This feeding behavior causes extensive cellular destruction and the formation of large necrotic cavities. These nematodes are significant pests of tropical crops like bananas and citrus.

17. (A) Migratory ectoparasite
Dagger nematodes, belonging to the genus Xiphinema, are classified as migratory ectoparasites. They possess long stylets that allow them to feed on deep root tissues while remaining outside the plant. They move between different locations on the root system, often targeting the meristematic regions. This feeding behavior causes root tip swelling and can facilitate the transmission of various plant viruses.

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the stylet. By providing this structural support, the framework ensures that the force generated by muscle contractions is efficiently translated into the powerful stylet thrusts required for cell penetration.

56. (B) The stomatostylet is characterized by basal knobs for muscle attachment
The stomatostylet, found in nematodes of the order Tylenchida, is a hollow tube with distinct basal knobs. These knobs serve as the attachment points for the muscles that drive the stylet's forward and backward movements. This anatomical feature is essential for the mechanical function of the stylet. In contrast, the odontostylet, found in Dorylaimida, lacks these specific basal knobs.

57. (C) Epidermal cell wall and surface cuticle
The first physical barrier a nematode must overcome to infect a plant is the outer boundary of the root, consisting of the epidermal cell wall and any associated surface cuticle or mucilage. This layer is often reinforced with complex polymers that require both mechanical force from the stylet and chemical degradation from secreted enzymes to breach. Success here is essential.

58. (A) Secretion of enzymes that dissolve the middle lamella
Intercellular migration is a strategy where the nematode moves between cells rather than through them. This is achieved by secreting specific enzymes, such as pectate lyases, that dissolve the middle lamella which holds adjacent cells together. This method causes less immediate damage to the host cells than intracellular migration and is often used by root-knot nematodes to reach the vascular.

59. (C) Sampling of cell contents and salivary secretion
Once a nematode successfully breaches a host cell wall with its stylet, it typically pauses to sample the internal contents of the cell. During this time, it also injects salivary secretions containing effectors and enzymes into the cytoplasm. This behavior allows the nematode to evaluate the host cell's status and begin manipulating its physiology for feeding or migration.

60. (A) II, III, I, IV
The progression of structural damage during endoparasite migration begins with the degradation of the middle lamella to separate cells. This is followed by the penetration of the primary cell wall using the stylet. Once the wall is breached, the plasma membrane is ruptured, leading to the release of cytoplasm. Finally, these events culminate in localized cellular necrosis and death.

61. (B) Effector proteins and hydrolytic enzymes
The secretions from the oesophageal glands of plant-parasitic nematodes are primarily composed of a complex mixture of effector proteins and hydrolytic enzymes. These molecules are essential for degrading plant cell walls, suppressing host immune responses, and manipulating cellular pathways to establish feeding sites. The specific composition of the secretome varies depending on the life stage and the host interaction.

62. (B) Dorsal gland
While the subventral glands are most active during the initial penetration and migration phases, the dorsal gland takes over a primary role once the nematode becomes sedentary. It secretes the effectors necessary for the establishment, modification, and long-term maintenance of specialized feeding sites like giant cells or syncytia. These secretions are critical for diverting host nutrients to the nematode.

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63. (B) They are acquired through horizontal gene transfer
The ability of plant-parasitic nematodes to produce their own cellulases is a remarkable evolutionary novelty. Molecular evidence suggests that the genes encoding these enzymes were acquired from soil bacteria or fungi through horizontal gene transfer. This allowed nematodes to independently digest cellulose, a capability not found in most other animals. This acquisition was a fundamental step in the evolution of plant parasitism.

64. (B) To break down pectin in the middle lamella
Pectate lyases are critical enzymes secreted by nematodes to facilitate tissue invasion. Their primary role is to degrade pectin, the complex polysaccharide that makes up the middle lamella and holds plant cells together. By breaking down this adhesive layer, the nematode can move

effector proteins into the cell to suppress host defenses and prevent the cell from reverting or collapsing. This ongoing chemical dialogue is essential for the stability of the parasitic relationship throughout the female's life.

84. (B) Undergoes rapid senescence and collapses
If the associated nematode dies or is removed, the giant cell quickly loses its specialized function. Without the continuous chemical stimuli and effector injections from the parasite, the cell's metabolic activity ceases, and it undergoes rapid senescence followed by cellular collapse. This demonstrates that the maintenance of the feeding site is an active process controlled by the nematode's secretions.

85. (B) Wall dissolution and fusion of adjacent protoplasts
Syncytia, induced by cyst nematodes, are formed through the progressive dissolution of cell walls between adjacent cells and the subsequent fusion of their protoplasts. This process creates a large, multinucleate cytoplasmic mass that incorporates many surrounding cells into a single functional unit. This mechanism is fundamentally different from the acytokinetic mitosis that produces the giant cells seen in root-knot nematodes.

86. (B) Heterodera
The genus Heterodera, which includes several important cyst nematode species, is primarily associated with the induction of syncytia in host roots. These feeding sites are complex, multinucleate structures formed by the fusion of hundreds of individual cells. This specialized adaptation is essential for the sedentary lifestyle of the female cyst nematode, providing the nutrients required for egg production.

87. (B) A syncytium is formed from cell fusion with wall remnants
The key structural difference between a syncytium and a giant cell lies in their formation. A syncytium results from the fusion of many existing cells after the partial dissolution of their walls, leaving behind characteristic wall remnants. In contrast, a giant cell is a single cell that undergoes repeated nuclear divisions without cytokinesis. Both serve as specialized nutrient transfer cells.

88. (A) Initial syncytial cell (ISC)
The process of syncytium formation begins when an infective cyst nematode juvenile selects a specific cell in the root vascular cylinder, known as the initial syncytial cell (ISC). After the nematode penetrates the ISC and begins feeding, the cell undergoes physiological changes that lead to the dissolution of neighboring cell walls and the expansion of the syncytium into surrounding tissues.

89. (B) Dense cytoplasm with organelles and plastids
A mature syncytium is characterized by a dense, granular cytoplasm that is rich in metabolic organelles such as mitochondria, endoplasmic reticulum, and plastids. This dense cytoplasm reflects the high metabolic rate required to support the sedentary nematode. Similar to giant cells, syncytia also show a reduction in large central vacuoles to maximize the volume of active metabolic space.

90. (B) Activation of endogenous plant wall-degrading enzymes
The breakdown of cell walls during syncytium formation is a coordinated process involving both nematode-secreted enzymes and the activation of the plant's own endogenous wall-degrading enzymes. The nematode's effectors hijack the host's cellular pathways to induce the expression of enzymes like cellulases and pectinases, which then act to dissolve the walls of neighboring cells, allowing for protoplast fusion.

91. (A) P-1, Q-2, R-3, S-4
Syncytia originate through cell fusion and are typically formed by Heterodera species. Giant cells originate by acytokinetic mitosis and are characteristic of Meloidogyne species. This matching correctly identifies the biological origins and the primary nematode genera associated with these two distinct types of specialized feeding structures. Understanding these differences is critical for studying nematode-host interactions at the cellular level.

92. (B) Early degradation preventing nematode maturation
In resistant plant varieties, the attempt by a cyst nematode to establish a syncytium is often met with a defensive response that leads to the early degradation of the feeding site. Without a functional and stable nutrient source, the nematode is unable to complete its development

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74. (B) Repeated DNA synthesis without cytokinesis
The immense size of a giant cell is driven by repeated cycles of DNA synthesis and nuclear division that are not followed by cytokinesis. This process, often involving endoreduplication, leads to a massive increase in cellular volume and DNA content. The expanded cell provides the large surface area and metabolic capacity required to function as a specialized nutrient sink for the sedentary nematode.

75. (B) High metabolic activity and abundant organelles
The dense, granular appearance of giant cell cytoplasm under a microscope is a reflection of intense metabolic activity. It contains a high density of organelles, including mitochondria, endoplasmic reticulum, and ribosomes, which are necessary for the rapid synthesis of proteins and other metabolites. This specialized cytoplasm is essential for sustaining the nematode and reflects the cell's role as a nutrient sink.

76. (B) Formation of extensive cell wall ingrowths
Mature giant cells develop extensive cell wall ingrowths, particularly on the walls adjacent to the plant's vascular elements. These labyrinthine structures significantly increase the surface area of the plasma membrane, facilitating the efficient uptake of solutes and nutrients from the xylem and phloem. This modification is a hallmark of transfer cells and is critical for the nematode's nutrition.

77. (B) Increasing surface area for solute uptake
The primary biological function of cell wall ingrowths in giant cells is to maximize the surface area of the plasma membrane. This increased area allows for a higher density of transporter proteins, which facilitates the rapid and efficient uptake of nutrients from the surrounding vascular tissues. This specialization ensures that the giant cell can act as a powerful metabolic sink.

78. (A) Both A and R are true and R is the correct explanation of A
Giant cells are correctly described as specialized transfer cells because their primary function is the high-volume transport of nutrients to the nematode. The development of complex cell wall ingrowths is the structural adaptation that enables this function by maximizing the membrane surface area available for transport. Therefore, the reason provided accurately explains the physiological status of the giant cell.

79. (B) Meloidogyne
The induction of true giant cells is a unique characteristic of the genus Meloidogyne. While other sedentary nematodes like Heterodera induce similar structures called syncytia, they are formed through a different mechanism involving cell wall dissolution and fusion. Understanding this distinction is fundamental in nematology, as the cellular and molecular pathways involved in the formation of these two feeding sites differ significantly.

80. (C) Usually 5 to 7 discrete giant cells
A single root-knot nematode feeding site typically consists of a small group of 5 to 7 discrete giant cells. These cells are clustered together around the nematode's head within the vascular cylinder. Each giant cell is individually induced and maintained by the parasite's secretions. Together, they provide the necessary nutrient supply to support the growth and reproduction of the female.

81. (B) Replication of the genome without nuclear division
Endoreduplication is a specialized cell cycle process where the genome is replicated multiple times without the occurrence of nuclear division or cytokinesis. This results in a massive increase in the DNA content within a single nucleus, often leading to polyploidy. In the context of giant cells, this process supports increased metabolic activity and cellular enlargement, contributing to their efficiency.

82. (C) Large central vacuole
As a root cell transforms into a giant cell, the large central vacuole typical of mature plant cells is notably reduced or completely disappears. It is replaced by a dense, organelle-rich cytoplasm and numerous small vacuoles. This structural change is necessary to accommodate the increased metabolic machinery required to process and transport nutrients to the sedentary nematode.

83. (B) Continuous stimulus from the feeding female nematode
The continuous maintenance and metabolic activity of a giant cell are entirely dependent on a persistent stimulus from the feeding female nematode. The nematode must regularly inject

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27. (A) Retention of eggs within the tanned cyst of the dead female
Cyst nematodes have evolved a unique survival mechanism where the body wall of the dead female tans and hardens into a protective cyst. This structure contains and protects hundreds of eggs from environmental stresses, predators, and pathogens for several years. The eggs inside only hatch in response to specific chemical cues from host root exudates, ensuring host availability.

28. (C) First molt inside the egg
In most plant-parasitic nematodes, the first molt occurs within the eggshell before hatching. This means that the individual that emerges from the egg is already a second-stage juvenile. This developmental timing is a characteristic feature of the group. The second-stage juvenile is typically the stage that must locate and penetrate the host plant to continue its life cycle.

29. (D) Sedentary species generally have a higher reproductive rate
Sedentary endoparasites generally achieve much higher reproductive outputs than migratory species due to their stable, nutrient-rich feeding sites. The establishment of giant cells or syncytia provides a massive, continuous supply of energy that supports the production of hundreds or even thousands of eggs per female. In contrast, migratory nematodes must expend more energy on movement and finding new cells.

30. (A) II and V
In sedentary nematode life cycles, females lose their mobility after establishing a feeding site and do not regain it after the fourth molt, making the second statement incorrect. Furthermore, many economically significant sedentary species, such as several Meloidogyne species, reproduce via parthenogenesis, making the fifth statement incorrect. Males typically remain vermiform, and juveniles are the primary migratory phase.

31. (B) Infective second-stage juvenile
The term "vermiform" refers to a worm-like, slender shape. In the genus Meloidogyne, this shape is characteristic of the second-stage juvenile, which must navigate through the soil and root tissues. As the female develops further and becomes sedentary, she loses this vermiform shape and becomes increasingly swollen. Adult males, however, regain a vermiform shape after their final molt.

32. (B) Ability to exit the root when resources deplete
Migratory nematodes possess the significant advantage of mobility, allowing them to exit a host root if the environment becomes unfavorable or if the local nutrient resources are exhausted. This adaptation enables them to survive fluctuating soil conditions and locate healthier host tissues. Unlike sedentary species, they are not permanently tied to a single feeding site, increasing their ecological resilience.

33. (C) Immature female
In the life cycle of the reniform nematode, Rotylenchulus reniformis, the immature female is the specific stage responsible for root penetration. After completing several molts in the soil without feeding, the young female locates a host and embeds her anterior portion into the root. She then becomes sedentary and establishes a feeding site, while her posterior body becomes reniform.

34. (D) Host plant nutritional status and population density
Sexual differentiation in many root-knot nematode populations is epigenetically influenced by environmental conditions within the host root. High population densities or poor host nutritional status often trigger second-stage juveniles to develop into males instead of females. This mechanism acts as a survival strategy, as males are mobile and do not require specialized feeding sites, reducing pressure on the host.

35. (C) Mitotic parthenogenesis
Many of the most economically damaging species of Meloidogyne, such as Meloidogyne incognita and Meloidogyne javanica, reproduce primarily through mitotic parthenogenesis. In this process, eggs are produced without meiosis or fertilization, resulting in offspring that are genetically identical to the parent. This strategy allows for rapid population growth and the successful exploitation of stable agricultural environments without the need for males.

36. (B) To protect eggs from desiccation and microbes
Female root-knot and reniform nematodes secrete a gelatinous matrix into which they deposit their eggs. This matrix serves several critical functions, including protecting the eggs from drying out and acting as a barrier against

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or reproduce. This failure of syncytium maintenance is a primary mechanism of host resistance.

93. (C) Females require larger syncytia to complete reproduction
There is a strong correlation between the size of a syncytium and the developmental requirements of the nematode. Developing females, which have high energy demands for producing hundreds of eggs, require significantly larger and more metabolically active syncytia than males. A syncytium that fails to grow sufficiently will result in stunted females or cause the juveniles to differentiate into males.

94. (B) Neighboring vascular parenchyma and endodermal cells
As a syncytium expands, it progressively incorporates neighboring cells into its structure. This expansion primarily involves the fusion of vascular parenchyma and endodermal cells located near the initial infection site. By incorporating these tissues, the syncytium establishes a robust connection to the plant's vascular system, ensuring a high-volume supply of nutrients for the sedentary female nematode's continued development.

95. (B) They undergo targeted widening before wall dissolution
During the very early stages of syncytium induction, plasmodesmata between the initial syncytial cell and neighboring cells often undergo targeted widening. This structural change facilitates the increased movement of molecules and signals between cells before the actual dissolution of the cell walls begins. This process is part of the initial physiological reprogramming required to start the fusion of host cell protoplasts.

96. (C) Multinucleate and hypertrophied
A fully developed syncytium is a multinucleate structure containing hundreds of nuclei derived from the fused host cells. These nuclei often become hypertrophied, showing an increase in size and DNA content through processes like endoreduplication. This multinucleate state is essential for coordinating the intense metabolic activity of the feeding site and supporting the large-scale protein synthesis required by the nematode.

97. (B) Pronounced root galling or knotting
The most iconic and easily recognizable macroscopic symptom of Meloidogyne infection is the formation of pronounced galls or knots on the host roots. These swellings are the result of abnormal cell division and enlargement induced by the nematode's secretions. Galling can vary in size and number depending on the host's susceptibility and the severity of the infestation.

98. (A) Hyperplasia and hypertrophy of cortical cells
The formation of root galls is primarily driven by two distinct host cellular responses: hyperplasia and hypertrophy. Hyperplasia refers to the abnormal increase in the number of cells through rapid division, while hypertrophy involves the excessive enlargement of individual cells. Together, these processes lead to the localized swelling of the root tissue surrounding the nematode's permanent feeding site.

99. (A) Trichodorus
The "stubby root" symptom is specifically associated with the feeding of nematodes in the genus Trichodorus and Paratrichodorus. These ectoparasites target the root tips, causing the cessation of meristematic activity and leading to short, thickened, and abnormally branched root systems. This damage significantly impairs the plant's ability to take up water and nutrients from the soil, leading to stunting.

100. (B) Extensive dark, necrotic lesions in the root cortex
Microscopic examination of roots infected by Pratylenchus species typically reveals extensive dark, necrotic lesions within the cortex. These lesions are caused by the migratory feeding behavior of the nematodes, which move through the tissue and destroy cells along their path. This localized cell death leads to browning and tissue collapse, which is visible as characteristic lesions on the root.

101. (B) Root pruning
Root pruning is a symptom characterized by a significant reduction in the overall mass and length of the root system without the formation of specific deformities like galls. It is often caused by nematodes that feed on root tips, leading to the death of the primary and lateral roots. This results in a sparse and stunted root system that cannot support growth.

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140. (A) The HG Type Test
In modern nematology, the older race classification for Heterodera glycines has been largely replaced by the more comprehensive HG (Heterodera glycines) Type test. This system provides a more detailed and accurate description of the virulence profile of an SCN population. It focuses on how well the population can reproduce on the various sources of resistance used in breeding.

141. (B) HG Type shows which resistance sources are overcome
The fundamental difference between the HG Type test and the older race test for soybean cyst nematode is that the HG Type test specifically identifies which of the commonly used sources of resistance are overcome by the population. This information is more directly useful to growers and breeders, as it indicates which resistant cultivars will fail in a given field.

142. (B) Pathotype Ro1 or Ro4
A Globodera rostochiensis population that fails to produce cysts on Solanum tuberosum ssp. andigena (which carries the H1 gene) but reproduces normally on standard susceptible potatoes is typically classified as pathotype Ro1 or Ro4. These pathotypes are avirulent to the H1 resistance source. This specific host response is a key diagnostic feature used to identify common and manageable populations.

143. (A) P-2, Q-3, R-4, S-1
Globodera rostochiensis uses the Ro nomenclature, while G. pallida uses the Pa system. Heterodera glycines is now primarily classified using the HG Type system. Meloidogyne incognita populations are traditionally categorized into races 1 through 4 based on their host range. This matching correctly pairs each important plant-parasitic nematode with its internationally recognized classification scheme for virulence and pathotypes.

144. (B) Number of newly formed cysts per root system
In differential host testing for cyst nematodes, the primary metric used to assess virulence is the number of newly formed cysts found on the root system of each test plant. This count is typically compared to the number of cysts on a known susceptible check. A high number of cysts indicates a compatible, virulent interaction, while few or none indicate resistance.

145. (C) Meloidogyne
The North Carolina Differential Host Test is a standard procedure specifically developed for the identification of species and physiological races within the genus Meloidogyne, the root-knot nematodes. By using a specific set of host plants, researchers can differentiate between the most economically important species, such as M. incognita, M. javanica, M. arenaria, and M. hapla, based on their reproduction.

146. (B) Six
The original North Carolina Differential Host Test utilizes six specific host plant species or cultivars to identify and differentiate common root-knot nematode species and their races. These plants include tobacco, cotton, pepper, watermelon, peanut, and tomato. The collective pattern of susceptibility or resistance across these six plants provides a diagnostic profile for the nematode population being tested.

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147. (D) Wheat (cv. PI 137739)
Wheat is not one of the standard plant species included in the original North Carolina Differential Host Test for root-knot nematodes. The test relies on tobacco, cotton, pepper, watermelon, peanut, and tomato. Each of these six plants has a well-defined response to the various species and races of Meloidogyne, allowing for their differentiation. Wheat is typically used for cereal cyst tests.

148. (C) Pepper (cv. California Wonder)
In the North Carolina test, Meloidogyne javanica is primarily differentiated from most races of M. incognita by its inability to reproduce on pepper (cv. California Wonder). While most M. incognita races can infect this pepper cultivar, M. javanica typically results in a resistant response. This distinction is a key step in identifying the species present in a field sample.

149. (C) Meloidogyne arenaria (Race 1)
Meloidogyne arenaria Race 1 is uniquely identified in the North Carolina Differential Host Test by its ability to readily infect and reproduce on peanut (cv. Florunner). In contrast, M. incognita and M. javanica populations are typically unable to reproduce on this host. This specific capability makes the peanut differential a critical tool for identifying M. arenaria within a field population.

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overnight as transpiration rates drop, but this daily stress significantly reduces growth.

112. (B) Foliar nematodes like Aphelenchoides
Above-ground symptoms like the crinkling, distortion, and necrosis of leaves are typically caused by direct feeding of foliar nematodes within the aerial tissues. Species such as Aphelenchoides inhabit the leaf mesophyll, where their activity leads to characteristic angular spots and structural damage. These symptoms are a direct result of the parasite's presence in the leaves, rather than root-level damage.

113. (B) Anguina tritici
Seed galls in wheat and other cereals are specifically caused by the nematode Anguina tritici. After infecting the developing floral tissues, the nematodes induce the formation of galls that replace the normal seed grains. These galls contain thousands of juveniles in an anhydrobiotic state. The presence of these dark, hardened masses significantly reduces grain quality and serves as the primary inoculum.

114. (C) Localized patches of stunted, yellowing plants
A highly indicative pattern of nematode infestation in an agricultural field is the appearance of localized, irregular patches of stunted and yellowing plants. This patchy distribution reflects the naturally aggregated or "clumped" distribution of nematodes in the soil. Unlike nutrient deficiencies or chemical injuries, which may be more uniform, nematode problems typically start in small areas and expand over time.

115. (C) Quantitative systemic symptoms
Reductions in the overall yield and the quality of harvestable produce are classified as quantitative systemic symptoms of nematode infection. These outcomes are the cumulative result of the various primary and secondary stresses imposed by the parasite on the host plant throughout the growing season. While less visually specific than galls, these economic impacts are the most significant consequence for agriculture.

116. (B) Reduced internode length and delayed flowering
Stunting caused by nematode infection is often accompanied by specific morphological changes in the shoot, such as reduced internode length. This compaction of the plant structure occurs because the compromised root system cannot support normal cell elongation and expansion. Additionally, the overall stress of the infestation frequently leads to delayed flowering and maturity, further reducing the potential for a successful harvest.

117. (B) II, III and IV
Above-ground symptoms are often indirect and can easily mimic nutrient deficiencies. Midday wilting is a reliable indicator of compromised root function, and patchy distribution in the field is a characteristic sign of nematode presence. However, these symptoms are not always a direct consequence of nematodes in aerial tissues, and seed galls contain nematodes, not just plant tissue.

118. (A) Nitrogen deficiency (generalized chlorosis)
Root nematode damage most commonly mimics the symptoms of nitrogen deficiency in plants, characterized by a generalized chlorosis or yellowing of the foliage. This occurs because the damaged roots are unable to absorb sufficient nitrogen from the soil, which is essential for chlorophyll production. Because the symptom is non-specific, soil and root analysis are often required to confirm nematode involvement.

119. (A) Ditylenchus dipsaci
The "tulip root" symptom in cereals, characterized by deformed and swollen leaf bases and twisted stems, is caused by infection with the stem and bulb nematode, Ditylenchus dipsaci. This nematode remains migratory and feeds on the parenchymatous tissues, causing cells to separate and the plant structure to become distorted. These distinctive macroscopic symptoms are diagnostic for this specific nematode pest.

120. (A) Non-specific and easily confused symptoms
Root examination is essential because the above-ground symptoms of nematode infection, such as stunting and yellowing, are non-specific and easily confused with other problems like nutrient deficiencies, drought, or soil-borne diseases. Direct observation of the root system for galls, lesions, or cysts is necessary to confirm the presence and identity of the nematode and to ensure an accurate diagnosis.

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feeding and inhibiting the activity of their secreted hydrolytic enzymes. These compounds can chemically interfere with the nematode's digestive processes and make the tissue less palatable or even toxic. This concentration in the endodermis acts as a critical internal barrier.

180. (A) It relies on complex and polygenic traits
Constitutive resistance is often more durable because it typically relies on complex, polygenic traits, such as overall cell wall thickness or a cocktail of different chemical compounds. Because multiple genes are involved, it is much more difficult for a nematode population to evolve a single mutation to overcome the defense. This contrasts with major-gene resistance, which is often easily bypassed.

181. (C) Post-infectional biochemical/active defense
The hypersensitive response (HR) is classified as a post-infectional biochemical or active defense. It is not present in the healthy plant but is rapidly activated only after the specific recognition of a pathogen or nematode. This response involves a sophisticated cascade of cellular signaling that leads to the production of toxins and programmed cell death to halt the parasite.

182. (A) I, II and IV
The hypersensitive response is triggered by the specific recognition of nematode effectors and involves rapid, localized programmed cell death. This process effectively starves biotrophic nematodes by destroying their potential feeding site before it can be established. Contrary to providing nutrients, the HR is a highly effective defensive mechanism that results in a resistant interaction between the plant and parasite.

183. (C) Browning of cells surrounding the nematode
A visually diagnostic event of the hypersensitive response in root tissues is the rapid browning of the cells immediately surrounding the nematode. this browning is a result of the oxidation of phenolic compounds into toxic quinones during the programmed cell death process. This localized necrosis is a clear macroscopic indicator that the plant has successfully recognized and halted the infection.

184. (A) Necrosis prevents giant cell formation
The hypersensitive response (HR) defeats sedentary endoparasites like Meloidogyne by initiating rapid necrosis of the host cells at the infection site. This localized cell death prevents the nematode from successfully inducing and maintaining the specialized giant cells required for its nutrition. Without a functional feeding site, the nematode cannot survive or reproduce, leading to a resistant interaction.

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185. (A) A thick layer of cork or wound periderm
Post-infectional structural resistance can involve the plant forming a thick layer of cork or wound periderm around the invading nematode or its feeding site. This physical barrier serves to isolate the parasite from the rest of the root tissue, potentially trapping it and cutting off its access to nutrients. This response is induced specifically as a reaction to tissue damage.

186. (A) Block xylem vessels to prevent spread
The formation of tyloses is an induced structural defense where outgrowths from parenchyma cells enter and block the xylem vessels. In the context of nematode infection, this process can prevent the spread of the parasite or its effectors through the vascular system. It can also isolate the damaged area, although it may also contribute to the plant's wilting.

187. (B) Reinforce the cell wall and plug the puncture
Callose deposition is a rapid, post-infectional response to the mechanical damage caused by a nematode's stylet. The plant deposits this complex polysaccharide at the site of penetration to reinforce the cell wall and plug the puncture. This attempt to seal the breach can prevent the further injection of effectors and protect the cell's integrity from being compromised by the parasite.

188. (B) The mitochondrion via release of cytochrome c
The mitochondrion plays a central role in orchestrating programmed cell death during the hypersensitive response. Through the regulated release of cytochrome c and other signaling molecules into the cytoplasm, the mitochondrion triggers the activation of the enzymatic cascades that lead to the rapid and organized breakdown of the cell. This process is essential for the effective execution of active resistance.

189. (B) It undergoes vacuolization and collapses
In a resistant plant reaction against cyst nematodes, a newly induced syncytium

Consequently, the functional lifespan of the resistance gene is shortened as the population shifts. This highlights the importance of rotating resistance sources and implementing integrated management strategies.

131. (B) Continuous planting of a highly resistant host
The evolution of a new pathotype is most likely to be accelerated by the continuous planting of a crop variety with high resistance. This provides constant and intense selection pressure, ensuring that only those rare individuals capable of overcoming the resistance can survive and reproduce. Over several seasons, these virulent individuals will dominate the population, leading to the "breakdown" of resistance.

132. (B) Presence of root galling and reproduction
Distinguishing between different races of Meloidogyne incognita relies on evaluating the presence and severity of root galling and the subsequent reproduction of the nematode on a standardized set of differential host plants. By observing which hosts are susceptible and which are resistant, researchers can categorize the population into a specific race. This phenotypic test remains a fundamental diagnostic tool.

133. (A) Ro1, Ro2, Ro3, etc.
The internationally recognized scheme for designating pathotypes of the golden potato cyst nematode, Globodera rostochiensis, utilizes the "Ro" prefix followed by a numeric identifier, such as Ro1, Ro2, or Ro3. This system is based on the nematode's ability to reproduce on specific Solanum clones containing different resistance genes. This standardization is vital for international quarantine and breeding programs.

134. (C) Pa1, Pa2, Pa3
For the white potato cyst nematode, Globodera pallida, the pathotypes are denoted using the "Pa" prefix followed by a numeric identifier, typically Pa1, Pa2, and Pa3. Like the Ro system for G. rostochiensis, these designations indicate which sources of host resistance the nematode population can overcome. Accurate identification of these pathotypes is essential for selecting resistant potato varieties for fields.

135. (A) Solanum
Differential host tests for both species of potato cyst nematodes, Globodera rostochiensis and G. pallida, traditionally utilize a series of clones and varieties from the plant genus Solanum. These differentials include both cultivated potatoes and related wild species that carry specific genes for resistance. By testing a nematode population against this standard set, researchers can determine its specific pathotype.

136. (B) Solanum tuberosum ssp. andigena varieties
The historical British pathotype scheme for potato cyst nematodes was primarily based on the host response of resistance derived from Solanum tuberosum ssp. andigena. This subspecies was a key source of the H1 resistance gene, which was effective against pathotype Ro1 of G. rostochiensis. Understanding the genetic origin of resistance is crucial for the development and deployment of resistant cultivars.

137. (C) Ro1
Pathotype Ro1 is considered the most globally widespread and economically significant pathotype of Globodera rostochiensis. It is found in many major potato-growing regions worldwide. Because many early resistant potato varieties were developed specifically to target Ro1 using the H1 gene, its identification remains a priority in diagnostic laboratories and international trade regulations. Success in Ro1 management is common.

138. (B) Wheat, barley, and oats
Pathotype classification for the cereal cyst nematode, Heterodera avenae, involves the use of differential varieties of major cereal crops, including wheat, barley, and oats. By testing a nematode population's ability to reproduce on specific cultivars of these grains, researchers can identify the particular pathotype present. This information is essential for advising farmers on crop rotation and variety selection.

139. (B) Four
The traditional race classification scheme for the soybean cyst nematode, Heterodera glycines, is based on the reproductive response of the nematode on four standard differential soybean lines. These lines, along with a universal susceptible variety, allow for the identification of 16 potential races. This system was used for decades to characterize the diversity and virulence of SCN populations.

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102. (B) Root proliferation behind the root tip
When nematodes feed at the root tip and cause it to stop growing, the plant often responds by initiating new lateral roots just behind the damaged area. This macroscopic symptom is known as root proliferation. This reaction is an attempt by the plant to compensate for the lost apical dominance and restore its root surface area for nutrient and water absorption.

103. (B) Cyst nematode adult females
The presence of tiny, white, pearl-like structures protruding from the root surface is a classic sign of cyst nematode infection. These structures are the swollen bodies of the adult females, which have broken through the root epidermis. As they mature and die, these females will eventually turn brown and harden into cysts, which contain the next generation of eggs.

104. (B) II, I, IV, III
The development of necrotic lesions following migratory endoparasite infection begins with the initial penetration of a host cell. This is followed by the breakdown of the cell wall and internal contents as the nematode feeds and moves. The subsequent release of cellular contents leads to tissue browning. Finally, these individual events coalesce into macroscopically visible necrotic lesions on the root.

105. (A) Ectoparasitic nematodes like Belonolaimus
Severe root pruning is most typically associated with high population densities of large ectoparasitic nematodes such as Belonolaimus, the sting nematode. These parasites feed aggressively on root tips and lateral roots, causing them to die back. At high densities, this feeding activity can effectively "prune" the entire root system, leading to extreme stunting and even plant death in the field.

106. (C) Secondary infection by soil-borne pathogens
Necrotic lesions caused by nematode feeding provide ideal entry points for various secondary soil-borne pathogens, including fungi and bacteria. These secondary invaders can significantly worsen the damage initiated by the nematodes, leading to rapid root rot and systemic decline of the plant. Such synergistic interactions often make the overall impact of the nematode infestation much more severe than direct feeding.

107. (A) Rapid localized cell death and browning
The microscopic hallmark of a successful hypersensitive response (HR) in root tissues is the rapid occurrence of localized cell death and associated browning around the nematode. This programmed cell death serves to isolate the parasite and destroy its potential feeding site. In resistant varieties, this response is triggered shortly after the nematode attempts to establish itself, effectively halting the infection.

108. (B) An abnormal increase in the number of cells
In the context of root galling induced by nematodes, hyperplasia refers specifically to the abnormal and rapid increase in the number of cells due to uncontrolled cell division. This process, along with cell enlargement, contributes to the overall growth of the gall tissue. It is a direct result of the nematode manipulating the plant's hormonal balance and developmental pathways.

109. (B) Stunting and patchy field growth
A classic systemic above-ground symptom of severe root nematode infection is the presence of stunting and patchy growth within the field. Because nematodes are rarely distributed uniformly, infested areas appear as localized spots of poor plant performance. These patches may gradually enlarge over several seasons. The affected plants appear smaller and less vigorous compared to those in healthy areas.

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110. (B) Impaired water and mineral nutrient uptake
Chlorosis, or the yellowing of leaves, caused by root-parasitic nematodes is primarily a secondary consequence of damaged root systems. The physical destruction of roots and the establishment of feeding sites impair the plant's ability to efficiently take up water and essential mineral nutrients, particularly nitrogen. This nutrient deficiency leads to a reduction in chlorophyll content, resulting in the chlorotic appearance.

111. (B) Midday wilting or temporary wilting
Midday or temporary wilting occurs when nematode-damaged roots cannot supply enough water to meet the high transpiration demands during the hottest part of the day. Even if soil moisture is adequate, the compromised root system lacks the hydraulic conductivity needed for rapid uptake. Affected plants may recover

150. (C) Four
The North Carolina Differential Host Test formally recognizes four distinct physiological races of Meloidogyne incognita. These races are identified based on their specific patterns of reproduction on tobacco (cv. NC 95) and cotton (cv. Deltapine). Correctly identifying these races is essential for recommending effective resistant cultivars and managing root-knot nematode problems in diverse cropping systems.

151. (A) Tobacco (NC 95) (-) and Cotton (Deltapine) (-)
Race 1 of Meloidogyne incognita is characterized by its inability to reproduce on both tobacco (cv. NC 95) and cotton (cv. Deltapine). This "minus/minus" response on these two key differentials distinguishes Race 1 from the other three races of the species. Since Race 1 is often the most common, its identification is a frequent requirement in diagnostic laboratories.

152. (A) Meloidogyne hapla
Meloidogyne hapla, the northern root-knot nematode, is known for inducing small, distinct galls that are often accompanied by extensive lateral root proliferation. In the North Carolina test, it is characterized by its ability to infect peanut but not watermelon. This species is better adapted to cooler climates and has a distinct morphological and parasitic profile compared to other root-knot species.

153. (B) It takes 45-60 days and greenhouse space
A significant limitation of the North Carolina Differential Host Test in modern diagnostics is the considerable time and resources it requires. The test typically takes between 45 and 60 days to complete and necessitates dedicated greenhouse or growth chamber space. This delay can be problematic when rapid identification is needed for making immediate planting or management decisions.

154. (B) Molecular and isozyme phenotyping
In modern diagnostics, the traditional host differential test for Meloidogyne is often supplemented or replaced by faster and more precise molecular and biochemical methods. These include DNA sequencing, PCR-based assays, and isozyme phenotyping, such as esterase and malate dehydrogenase analysis. These techniques provide definitive species identification within a few days, significantly reducing the time required for diagnosis.

155. (C) Tomato (cv. Rutgers)
In the North Carolina Differential Host Test, tomato (cv. Rutgers) serves as the universal susceptible check. Because this cultivar is highly susceptible to all common root-knot nematode species, it is used to confirm that the nematode inoculum is viable and that the environmental conditions are favorable for infection. If the tomato plant does not show heavy galling, the test is invalid.

156. (D) I, II and III
All three statements regarding the North Carolina Differential Host Test are correct. It utilizes six specific plant cultivars, uses a plus (+) and minus (-) rating system to indicate host status, and is capable of identifying specific races within species like M. arenaria and M. incognita. This comprehensive system remains a benchmark for phenotypic characterization in plant nematology.

157. (B) Susceptible
A host plant that allows high levels of nematode reproduction and suffers significant damage or yield loss is defined as susceptible. This represents a fully compatible interaction where the plant's defenses are absent or effectively suppressed by the parasite. Susceptible cultivars are the most vulnerable and contribute to the rapid increase of nematode population densities in the soil.

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158. (C) It suppresses or prevents reproduction
In plant nematology, resistance is strictly defined by the plant's ability to suppress or prevent the reproduction of the nematode. A resistant plant may still be penetrated by juveniles and show some symptoms of damage, but the failure of the nematode to produce eggs means the population density will decrease over time. This is the most critical trait for breeding.

159. (C) Tolerant
A tolerant plant variety is one that can sustain a high level of nematode reproduction without suffering significant damage or yield loss. While the plant appears healthy and productive, it acts as a good host, allowing the soil nematode population to increase. Tolerance is a valuable trait for yield stability but must be managed carefully to avoid long-term population buildup.

160. (B) Intolerant or hypersensitive plant
An intolerant or hypersensitive plant is one that suffers extreme damage even at low nematode densities. In some cases, the plant cells die so quickly after infection that the nematode is unable to establish a feeding site and reproduce. While this prevents the population from increasing, the severe damage to the host makes it unsuitable for agricultural production.

161. (A) Absolute non-host status for infection
Immunity in a plant refers to an absolute non-host status, where the nematode is completely unable to infect or reproduce on the plant. This is the highest level of resistance and is relatively rare in plant-nematode interactions. Immune plants do not trigger a defense response because the nematode cannot initiate any part of the parasitic process.

162. (C) Both resistant and tolerant, or the inverse
Because resistance and tolerance are genetically independent traits, a plant variety can exhibit any combination of these characteristics. A cultivar can be both resistant and tolerant, susceptible and tolerant, or resistant and intolerant. Understanding these distinctions is crucial for plant breeders and growers when selecting varieties that both protect yield and reduce soil nematode populations.

163. (B) Reduce soil nematode population density
The primary goal of breeding for nematode resistance in agriculture is to reduce the overall population density of the parasite in the soil. By preventing or suppressing nematode reproduction, resistant cultivars help to protect not only the current crop but also future crops in the rotation. This sustainable approach reduces the reliance on chemical nematicides and improves soil health.

164. (C) It builds up high soil populations
The main agricultural drawback of planting a highly tolerant but susceptible crop variety is that it allows for the rapid buildup of high nematode populations in the soil. While the current crop may yield well, the massive increase in nematodes can cause severe damage to subsequent, non-tolerant crops in the rotation. This makes long-term management much more difficult.

165. (B) Nematode reproduction factor
The host status of a plant is primarily determined by evaluating the nematode reproduction factor (Rf or $\frac{Pf}{Pi}$). This metric measures the ability of the nematode to multiply on the host over a specific period. A high reproduction factor indicates a susceptible host, while a low factor indicates resistance. This quantitative assessment is more reliable than observing visual symptoms alone.

166. (C) Resistant or a poor host
A reproduction factor (Rf) of less than 1.0 indicates that the final nematode population (Pf) is smaller than the initial population (Π). This means that the plant has suppressed nematode multiplication, classifying it as a resistant or poor host. Using such plants in a rotation is a key strategy for reducing soil-borne nematode densities over time.

167. (A) Crop that does not support reproduction
A non-host crop is defined as one that does not support the reproduction of a specific nematode species. While the nematode might occasionally penetrate the roots, it cannot complete its life cycle. Including non-host crops in a rotation is one of the most effective and sustainable ways to manage nematode populations by starving them in the absence of a host.

168. (B) It is a common post-infectional mechanism for resistance
The hypersensitive response (HR) is a common post-infectional mechanism used by plants to achieve resistance. When the plant recognizes the presence of a nematode through specific molecular interactions, it triggers localized cell death at the infection site. This necrotic barrier prevents the nematode from establishing a feeding site and effectively halts the parasitic process, resulting in a resistant host.

169. (B) Pre-existing structural barriers → Constitutive chemical defenses → Induced structural defenses → Induced biochemical defenses
A nematode sequentially encounters different levels of plant defense during the infection process. It first meets pre-existing physical barriers like the root epidermis. This is followed by constitutive chemical defenses present in healthy tissues. If these are breached, the plant may activate induced structural defenses and, finally, sophisticated induced biochemical

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responses like the hypersensitive response to halt the parasite.

170. (C) Are naturally present in the plant regardless of nematode presence
Constitutive resistance refers to plant defense mechanisms that are naturally and permanently present, even in the absence of any nematode or pathogen attack. These "always-on" defenses include physical structures like thick cell walls and pre-existing chemical compounds like toxins or enzyme inhibitors. They serve as the first line of defense, providing a baseline level of protection.

171. (B) Thick, heavily suberized or lignified exodermis
A thick and heavily suberized or lignified exodermis is a classic example of a pre-infectional structural barrier. This physical reinforcement of the outer root layers makes it much more difficult for a nematode to mechanically penetrate the tissue with its stylet. Such barriers are present before any contact with the parasite and provide a constitutive level of resistance against many.

172. (B) Lignin physically resists the stylet thrusts
High constitutive levels of lignin in root tissues provide resistance by making the cell walls much tougher and more rigid. This physical reinforcement directly resists the mechanical force of the nematode's stylet thrusts, often preventing the parasite from successfully puncturing the cells. Lignin is difficult for the nematode's enzymes to degrade quickly, effectively acting as a strong structural barrier.

173. (A) Alpha-tomatine in tomato roots
Alpha-tomatine is a naturally occurring glycoalkaloid found in the roots of certain tomato varieties. It is an example of a pre-infectional (constitutive) chemical defense because it is present in the tissue at toxic levels even before a nematode attack. This compound can inhibit the growth or survival of the parasite upon contact, providing a baseline level of chemical resistance.

174. (B) Physically trapping or repelling the nematodes
The root cap and the mucilage it secretes can act as constitutive defenses by creating a physical and chemical environment that is unfavorable for nematodes. The mucilage can trap or slow down the parasites as they attempt to reach the root, while the root cap cells can act as a sacrificial barrier or release repulsive compounds into the surrounding soil.

175. (B) Alpha-terthienyl
Marigolds (Tagetes spp.) are well-known for their ability to suppress soil nematode populations. This is primarily due to the constitutive production and exudation of alpha-terthienyl, a potent nematicidal compound, from their roots. This compound is toxic to many nematode species upon contact, making marigolds a popular choice for cover crops and companion planting in integrated nematode management programs.

176. (B) High calcium pectate in the middle lamella
High levels of calcium pectate in the middle lamella provide a constitutive structural barrier against intercellular migration. This compound strengthens the "glue" that holds plant cells together, making it more difficult for nematodes to dissolve the lamella and separate the cells using their secreted pectate lyase enzymes. This increased structural integrity can slow down or prevent the nematode's progress.

177. (A) Acting as a physical impediment to nematodes
A high density of root hairs can influence nematode infection by acting as a physical impediment or a confusing environment for the parasite as it searches for a suitable penetration site. In some cases, the dense hairs can interfere with the nematode's ability to gain the mechanical leverage needed to thrust its stylet into the epidermal cells, providing a barrier.

178. (A) Disrupting nematode cell membranes on contact
Saponins are a class of constitutive chemical compounds found in many plant roots that act defensively by disrupting the cell membranes of nematodes. Their detergent-like properties interfere with the integrity of the nematode's external and internal membranes, leading to cellular leakage and death. This chemical barrier is present in the healthy plant and serves as a significant deterrent to feeding.

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179. (B) Deter feeding and inhibit hydrolytic enzymes
A high baseline concentration of phenolic compounds in the endodermal cells serves as a constitutive defense by deterring nematode

121. (B) Can overcome specific host resistance genes
In nematology, the term "pathotype" refers specifically to a population within a nematode species that possesses the ability to overcome the resistance provided by certain genes in a host plant. Identifying pathotypes is crucial for selecting the appropriate resistant cultivars for a given field. This classification is based on the nematode's functional interaction with host genetics rather than morphological differences.

122. (B) A population with a specific trait
A "biotype" generally refers to a population of organisms that share a specific biological or physiological trait. In the context of nematodes, this could include a group with a particular host range, temperature tolerance, or reproductive behavior. While similar to pathotypes, the term biotype is often broader and may not specifically refer to the ability to overcome defined resistance genes.

123. (B) Intensive monoculture using R-gene cultivars
The emergence of new pathotypes or physiological races is primarily driven by the intensive monoculture of crop cultivars containing major resistance (R) genes. This practice imposes strong directional selection pressure on the nematode population. Any individuals that possess the rare ability to overcome the resistance will survive and multiply, eventually leading to a population that can bypass that specific host.

124. (C) Selection acting on pre-existing variation
The emergence of resistance-breaking pathotypes, even in parthenogenetic nematodes like Meloidogyne, is largely due to selection acting on rare, pre-existing genetic variation within the population. When a resistant cultivar is deployed, individuals with the specific genetic makeup to bypass that resistance are favored. Over time, these virulent variants become the dominant part of the population, rendering the resistance gene ineffective.

125. (B) The ability to reproduce on differential hosts
A physiological race in root-knot nematodes is defined primarily by its specific host range, as determined by the ability to reproduce on a set of standardized differential host plants. This classification system allows researchers to distinguish between populations that may appear morphologically identical but have different parasitic capabilities. This is critical for predicting the effectiveness of crop rotations and resistant cultivars.

126. (B) It determines the appropriate cultivar to deploy
Pathotype designation is crucial for effective nematode management because it determines which resistant cultivars will be successful in a particular field. Knowing the specific pathotype present allows growers to select varieties that the nematode cannot infect. This targeted approach prevents yield loss and helps maintain the longevity of resistance genes by avoiding the use of ineffective or easily overcome cultivars.

127. (B) Virulence
Virulence is the genetic term that describes the ability of a nematode pathotype to successfully infect and reproduce on a host plant carrying a specific resistance gene. A virulent population can overcome the host's defense mechanisms. In contrast, avirulence refers to the inability of a nematode to reproduce on a resistant host because its presence is recognized by the plant's defenses.

128. (B) Compatible (Reproduction occurs normally)
If a nematode population lacks the specific avirulence (Avr) gene that is recognized by a plant's resistance (R) gene, the host is unable to detect the parasite and trigger a defense response. The resulting interaction is compatible, meaning that the nematode can successfully establish a feeding site and reproduce normally. This is how "virulence" is manifested at the molecular level.

129. (B) Adapt host preference based on cues
Phenotypic plasticity in certain nematode biotypes allows them to adapt their behavior or physiology based on environmental cues, such as the type of host plant available. This flexibility can include adjusting host preferences or reproductive strategies. While it does not involve rapid changes to the DNA sequence itself, it enables populations to survive and thrive across a wider range of conditions.

130. (A) Both A and R are true and R is the correct explanation of A
The continuous use of a single resistant cultivar creates intense selection pressure that favors any rare nematode variants capable of overcoming that resistance. These virulent pathotypes will multiply while others are suppressed.

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typically fails to develop properly. Instead of becoming a dense metabolic sink, it undergoes rapid vacuolization and eventual collapse. This breakdown of the feeding site is often accompanied by localized necrosis, effectively starving the nematode and preventing it from reaching maturity or producing any eggs.

190. (A) P-1, Q-2, R-3, S-4
Lignin in the exodermis is a constitutive structural defense, while callose formation is an induced structural response. Alpha-tomatine represents a constitutive chemical defense, and the hypersensitive response (HR) is an induced biochemical defense. This matching correctly categorizes different types of plant defenses based on whether they are physical or chemical and whether they are pre-existing or induced.

191. (B) Phenolics oxidized to toxic quinone compounds
The characteristic browning associated with the hypersensitive response (HR) is primarily caused by the rapid oxidation of phenolic compounds. When cell membranes are compromised during programmed cell death, enzymes like polyphenol oxidase come into contact with phenolics, converting them into toxic quinone compounds. These quinones then polymerize to form the dark pigments seen as browning at the infection site.

192. (B) After specific recognition of PAMPs or effectors
Because induced resistance responses are highly energy-intensive and can be damaging to the host's own tissues, they are not active continuously. Instead, the plant only activates these sophisticated defenses after the specific recognition of pathogen-associated molecular patterns (PAMPs) or secreted nematode effectors. This targeted activation ensures that the plant conserves energy until a real threat is detected.

193. (B) A dominant R gene and a matching Avr gene
Flor's gene-for-gene hypothesis states that a resistant or incompatible interaction occurs only when a plant carries a dominant resistance (R) gene and the pathogen possesses a corresponding and matching avirulence (Avr) gene. If either the specific R gene or the matching Avr gene is missing, the interaction will be compatible, allowing the nematode to successfully infect and reproduce.

194. (C) A receptor that recognizes the Avr protein
In the gene-for-gene model, the product of the plant's resistance (R) gene typically functions as a highly specific receptor. This R protein is designed to recognize and bind to the specific avirulence (Avr) protein secreted by the nematode. This binding event acts as a molecular trigger, initiating the complex signaling cascade that leads to the activation of defenses.

195. (A) Both A and R are true and R is the correct explanation of A
If a nematode population acquires a mutation in an avirulence (Avr) gene, the resulting protein may no longer be recognized by the corresponding plant resistance (R) protein. This "evasion" prevents the activation of the host's defense responses, rendering the plant susceptible despite possessing the R gene. This mechanism is the primary way that virulent nematode pathotypes emerge in fields.

196. (A) NBS-LRR (Nucleotide-Binding Site Leucine-Rich Repeat)
The vast majority of cloned plant resistance genes that target nematodes belong to the NBS-LRR class of proteins. These proteins are characterized by a conserved nucleotide-binding site and a series of leucine-rich repeats. They function as intracellular receptors that detect the presence of specific nematode effectors, acting as the primary sensors in the plant's effector-triggered immunity system.

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197. (B) Protein-protein interaction and recognition
The Leucine-Rich Repeat (LRR) domain of a resistance (R) protein is primarily responsible for the specificity of the defense response. It facilitates the protein-protein interactions necessary for the recognition of specific nematode effectors. Variations in the LRR sequence allow different R proteins to detect a wide array of diverse parasite molecules, making it the key recognition component of the system.

198. (B) R protein monitors a host target protein
The Guard Hypothesis suggests that some R proteins do not recognize nematode effectors directly. Instead, they "guard" a specific host protein that is the intended target of a nematode's virulence effector. When the effector modifies or disrupts this target protein, the R protein detects the change and triggers the defense response.

the plant in large quantities only following the recognition of a pathogen or nematode. Their synthesis is a hallmark of the plant's induced immune response. These proteins serve various defensive roles, including degrading the parasite's structures or acting as signaling molecules to strengthen systemic immunity.

258. (B) Chitinases (PR-3)
Chitinases, which belong to the PR-3 class of pathogenesis-related proteins, are enzymes that degrade chitin, a structural polymer found in the cell walls of fungi and the eggshells and cuticles of some nematodes. While plants do not contain chitin, they upregulate these enzymes during nematode infection as part of a broad, induced defense response designed to target parasitic structures.

259. (B) They inhibit digestive proteases of the nematode
Proteinase inhibitors (PIs) play a significant role in plant defense by specifically inhibiting the digestive proteases of the nematode. When the parasite feeds on plant tissue containing high levels of PIs, its ability to break down and absorb proteins is severely compromised. This leads to nutrient deficiency, reduced growth, and decreased reproductive potential, effectively acting as a chemical deterrent to parasitism.

260. (A) P-2, Q-3, R-4, S-1
Phytoalexins are de novo synthesized antimicrobial compounds, while proteinase inhibitors inactivate nematode digestive enzymes. Phenolics serve as precursors for toxic quinones and lignin, and callose provides physical plugging of penetration sites. This matching correctly identifies the specific biological and chemical functions of these different components in the plant's overall induced defense strategy against nematode infection in various host tissues.

261. (B) Salicylic Acid
The establishment of Systemic Acquired Resistance (SAR) throughout the plant is dependent on a mobile signaling molecule that moves from the initial infection site to healthy tissues. This systemic signal is largely derived from the salicylic acid (SA) pathway. Recognition of the nematode triggers SA production, which then coordinates the activation of defense genes in distant plant parts.

262. (B) Active suppression of host defense
In compatible interactions, nematode feeding sites often show a marked decrease in the expression of host defense-related genes. This phenomenon is known as the active suppression of host defense. By secreting specific effectors, the nematode hijacks the plant's internal signaling pathways to "turn off" its immune responses. This suppression is essential for the establishment and long-term maintenance of biotrophic sites.

263. (B) Modulators of auxin transport and movement
Flavonoids are a class of secondary metabolites that can influence the success of a nematode infection by acting as modulators of auxin transport. By interfering with the plant's auxin carrier proteins, flavonoids can affect the localized accumulation of auxin required for the induction of feeding sites. This chemical interaction highlights the complex ways that plant metabolism can influence parasite success.

264. (C) PPO oxidizing phenolics into quinones
The rapid browning seen in resistant roots exhibiting an HR is the visible result of the enzyme polyphenol oxidase (PPO) oxidizing phenolic compounds into highly reactive and toxic quinone compounds. These quinones then polymerize to form dark, insoluble pigments. This biochemical reaction is a key component of the localized necrotic response that isolates and halts the invading nematode.

265. (B) THE sudden and massive production of Reactive Oxygen Species (ROS)
The "oxidative burst" is a rapid and transient defensive response in plants characterized by the sudden and massive production of reactive oxygen species (ROS). This event occurs shortly after the plant recognizes a pathogen or nematode. The burst of ROS serves as a direct toxin to the parasite and as a critical signaling molecule that triggers further defense responses.

266. (A) Hydrogen peroxide (H2O2)
Hydrogen peroxide (H2O2) is one of the primary reactive oxygen species (ROS) produced by plants during the oxidative burst following nematode recognition. It is relatively stable and can diffuse through membranes, allowing it to function both as a direct antimicrobial agent and as a key signaling molecule that coordinates

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pairs some of the most important and well-studied cloned nematode resistance genes with the specific nematode pests they were developed to manage in various agricultural crops.

209. (C) Heterodera schachtii
The Hs1pro-1 gene was the first resistance gene cloned from sugar beet and specifically provides resistance against the sugar beet cyst nematode, Heterodera schachtii. This gene was successfully transferred from a wild relative into cultivated sugar beet to help manage this devastating pest. It represented a major milestone in the molecular breeding of sugar beet for nematode resistance.

210. (B) Transmembrane protein with extracellular LRR
The Hs1pro-1 gene encodes a unique class of resistance protein that functions as a transmembrane protein with an extracellular leucine-rich repeat (LRR) domain. This structure suggests that it may recognize nematode effectors or signals outside the host cell or at the plasma membrane. This differs from the more common intracellular NBS-LRR proteins that characterize many other nematode resistance genes.

211. (B) Globodera pallida
The Gpa2 gene was cloned from potato and specifically confers resistance against certain populations of the white potato cyst nematode, Globodera pallida. It belongs to the NBS-LRR class of resistance genes. Identifying and deploying such genes is essential for potato growers, as G. pallida is often more difficult to manage than G. rostochiensis and has fewer available sources.

212. (B) Potato Virus X (PVX)
The Gpa2 gene in potato is notable for sharing high sequence homology with the Rx1 gene, which provides resistance against Potato Virus X (PVX). Both genes are located in a similar genomic cluster and belong to the same family of NBS-LRR proteins. This evolutionary relationship suggests that these genes may have common origins and share similar molecular mechanisms.

213. (B) Both Globodera rostochiensis and G. pallida
The Hero A gene, cloned from tomato, is highly valuable because it confers broad-spectrum resistance against both major species of potato cyst nematodes, Globodera rostochiensis and G. pallida. This level of cross-species resistance is relatively rare among R genes. Its ability to target multiple pathotypes within both species makes it a powerful tool for developing resistant varieties for infested soils.

214. (A) Globodera rostochiensis
Gro1-4 is a specific resistance gene derived from the wild potato relative Solanum spegazzinii. It targets pathotypes of the golden potato cyst nematode, Globodera rostochiensis. This gene has been used in potato breeding programs to provide high levels of resistance against this important pest. Its successful cloning has allowed for a better understanding of its function and molecular mechanism.

215. (B) Copy number variation of a block of three genes
The Rhg1 locus is the most important source of resistance against soybean cyst nematode, Heterodera glycines. It is unusual because the resistance is not mediated by a single NBS-LRR gene. Instead, it is caused by copy number variation of a genomic segment containing three different genes. Plants with more copies of this segment exhibit higher levels of resistance.

216. (B) Host-Induced Gene Silencing via RNAi
Host-Induced Gene Silencing (HIGS) via RNA interference (RNAi) is a transgenic approach that can provide resistance by specifically degrading essential nematode mRNA. The plant is engineered to produce double-stranded RNA that matches a vital nematode gene. When the nematode feeds, it ingests this RNA, which triggers the silencing of its own target gene, leading to death or starvation.

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217. (C) Root-knot nematodes
The Gall Index is a quantitative screening tool specifically designed to assess the level of damage and infection caused by root-knot nematodes of the genus Meloidogyne. Because these nematodes induce characteristic swellings or galls on the roots, the index provides a standardized way to visually estimate the severity of the infestation and the susceptibility of the host plant.

218. (A) No galls are present
In the standard 0 to 5 Gall Index scale, a rating of 0 indicates that no galls or knots are visible on the root system. This score is typical of highly resistant or immune plants that have successfully

prevented the nematode from inducing any tissue swelling. A zero rating is the ideal outcome in resistance screening and cultivar evaluation.

219. (C) 3
According to many commonly used 0 to 5 Gall Index scales, a root system where approximately 50% of the roots exhibit galling would receive a score of 3. This indicates a moderate to high level of infection. The scale is designed to provide a rapid visual estimate of damage, with higher numbers representing increasingly severe symptoms and greater susceptibility.

220. (D) A is false but R is true
The assertion that the Gall Index alone perfectly measures the reproduction rate of Meloidogyne is false. While it measures damage, it does not always correlate perfectly with egg production. Some plant varieties may exhibit significant galling (hyperplasia) but fail to support successful egg production by the nematode. Therefore, the reason provided is true and correctly identifies a limitation.

221. (B) I, III, II, IV
The correct sequence for determining the reproduction factor ($\frac{Pf}{Pi}$) in a greenhouse trial begins with inoculating the plant with a known initial population (Π). The plant is then grown for an appropriate duration, after which the final nematode population (Pf) is extracted from the soil and roots. Finally, the ratio of Pf to Π is calculated.

222. (B) 5.0
The reproduction factor (Rf) is calculated by dividing the final population (Pf) by the initial population (Π). In this scenario, dividing 5,000 eggs by the 1,000 eggs used for inoculation results in a reproduction factor of 5.0. This indicates that the nematode population increased fivefold during the experiment, identifying the plant as a susceptible host for that species.

223. (B) The actual host status of the tested plant
The Oostenbrink reproduction factor (Rf) calculation is widely considered the most reliable quantitative indicator of the actual host status of a plant. Unlike visual damage indices, the Rf measures the nematode's biological success in terms of multiplication. An Rf value greater than 1.0 identifies a susceptible host, while values below 1.0 indicate varying levels of resistance.

224. (B) Cyst index
The cyst index is a specialized screening tool that focuses on estimating the density or proportion of the root system covered by the bodies of mature female cyst nematodes. It is used specifically for species in the genera Heterodera and Globodera. This index provides a visual measure of infection severity that is analogous to the gall index for root-knot.

225. (A) Uneven distribution of nematodes in the soil
In field screening, the naturally aggregated and uneven distribution of nematodes in the soil can severely skew Gall Index results. Because some plants may coincidentally be located in areas with very high or low initial populations, the observed damage may not accurately reflect the plant's true genetic resistance. This environmental "noise" must be controlled through careful design and replication.

226. (C) Immediately before or at the time of planting
To determine the initial population (Π) for a field experiment, soil sampling should ideally occur immediately before or at the exact time of planting. This timing provides the most accurate measure of the nematode pressure that the young crop will face as it begins to grow. Knowing the Π is essential for correctly calculating the reproduction factor at harvest.

227. (A) Immune or extremely resistant host variety
A reproduction factor ($\frac{Pf}{Pi}$) of 0 indicates that no new nematodes were produced on the host plant. This outcome identifies the plant as either immune or an extremely resistant host variety. In such a plant, the nematode may be unable to penetrate, establish a feeding site, or complete any part of its reproductive cycle, effectively eliminating the population.

228. (B) Phloxine B
Phloxine B is a dye commonly used in nematology to stain the gelatinous egg masses of root-knot nematodes. It specifically colors the proteinaceous matrix red, making the egg masses clearly visible against the lighter-colored root tissue. This staining technique greatly facilitates the rapid and accurate counting of egg masses, which is a key metric in host susceptibility trials.

229. (B) Decreasing conductivity and inducing stress
Heavy infection by root-knot nematodes typically alters the host plant's water relations

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by decreasing root hydraulic conductivity. The presence of galls and the establishment of feeding sites disrupt the normal flow of water through the vascular system. This impairment leads to increased water stress in the shoot, even when soil moisture is adequate, resulting in symptoms like midday wilting.

230. (B) Disruption of xylem around feeding sites
The reduction in root hydraulic conductivity in nematode-infected plants is primarily attributed to the physical and physiological disruption of the xylem vessels. As giant cells or syncytia develop and expand, they can compress or displace nearby xylem elements. This structural change creates a "bottleneck" that resists the upward movement of water, leading to compromised water supply to the shoot.

231. (C) Reduction due to stomatal closure and chlorophyll
Nematode infection typically leads to a significant reduction in the host plant's rate of photosynthesis. This decrease is caused by a combination of factors, including stomatal closure in response to water stress and a reduction in chlorophyll content due to nutrient deficiencies. These indirect effects of root damage severely limit the plant's ability to produce energy for its growth.

232. (A) Nitrogen
While the uptake of many mineral nutrients is impaired by nematode damage, nitrogen deficiency is the macronutrient issue most frequently manifested through visible symptoms. The yellowing of leaves and reduced plant vigor are characteristic of nitrogen-starved plants. Because nematodes disrupt the most active nutrient-absorbing regions of the root, the plant's nitrogen status is often the first to be compromised.

233. (B) Feeding sites acting as strong metabolic sinks
The concept of "sink competition" refers to the fact that nematode feeding sites, such as syncytia and giant cells, function as powerful metabolic sinks. They actively divert photosynthates and other nutrients away from the plant's normal growth areas, like new leaves and developing fruits. This diversion of resources to the parasite significantly reduces the host's overall biomass and harvest.

234. (A) I, II, III and V
Nematode infection leads to several physiological changes: transpiration rates decrease due to stomatal closure, feeding sites accumulate imported sucrose, xylem disruption reduces shoot water potential, and nutrient translocation is impaired. However, photosynthetic efficiency is typically reduced rather than enhanced. These collective stresses significantly impact the plant's overall health and productivity, explaining the severe stunting and yield loss often observed.

235. (B) Sucrose transporters and amino acid permeases
To sustain the high metabolic activity required to feed a sedentary nematode, feeding cells like syncytia upregulate the expression of genes encoding sucrose transporters and amino acid permeases. These proteins facilitate the rapid and massive influx of energy-rich molecules from the plant's vascular system into the feeding site. This molecular reprogramming ensures that the site remains a dominant sink.

236. (B) Altered susceptibility to secondary pathogens
Changes in the carbon-to-nitrogen ($C{:}N$) ratio of the host plant due to nematode infection can significantly alter its overall physiology and its interaction with other organisms. One major consequence is a change in the plant's susceptibility to secondary pathogens, such as fungi and bacteria. These metabolic shifts can weaken the plant's defenses or provide a more favorable environment.

237. (B) A lower shoot-to-root ratio in the host
Nematode infection often alters the partitioning of biomass within the plant, generally resulting in a lower shoot-to-root ratio. While the root system may be heavily galled or damaged, the plant often allocates a higher proportion of its limited resources to root growth in an attempt to compensate for the lost function. This comes at the expense of shoot development.

238. (B) Cleave imported sucrose into glucose and fructose
Invertase enzymes are frequently upregulated in giant cells and syncytia. Their primary role is to cleave the imported sucrose, which is the plant's main transport sugar, into glucose and fructose. This breakdown increases the concentration of hexose sugars within the feeding site, which not only provides energy but also helps maintain the

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276. (A) DAB (3,3'-diaminobenzidine)
The localized accumulation of reactive oxygen species, particularly hydrogen peroxide, at the site of nematode penetration can be visualized using DAB (3,3'-diaminobenzidine) staining. In the presence of peroxidase enzymes, DAB reacts with hydrogen peroxide to form a visible brown precipitate. This histochemical technique is widely used in laboratory studies to identify and quantify the early oxidative defense response.

277. (B) Secretion of proteins similar to host proteins
Molecular mimicry is a sophisticated evolutionary strategy used by plant-parasitic nematodes, involving the secretion of effector proteins that are structurally or functionally similar to the host's own proteins. By mimicking these host molecules, the nematode can hijack and manipulate endogenous signaling pathways, such as those regulating growth and development, to establish its feeding site and suppress plant defenses.

278. (B) Stem cell maintenance and differentiation in meristems
In healthy plants, endogenous CLE (CLAVATA3/ Endosperm Surround Region-related) peptides function as critical signaling molecules that regulate the balance between stem cell maintenance and differentiation within the plant's meristems. They interact with specific receptor-like kinases to coordinate growth. Nematodes have evolved to produce their own CLE-like mimics to specifically target these pathways and reprogram root cell development during parasitism.

279. (B) Hijack plant signaling to promote syncytia
By secreting CLE-like peptides into the root tissue, cyst nematodes are able to hijack the plant's own developmental signaling pathways. These mimics allow the parasite to manipulate the host cells to promote the formation and expansion of a syncytium. This molecular strategy is a key component of the nematode's ability to transform normal root cells into a specialized nutrient sink.

280. (C) Secreted cyclins or cyclin-like proteins
Certain nematode species secrete cyclins or cyclin-like proteins that mimic plant cell cycle regulators. By delivering these mimics into the host cell, the nematode can directly influence the cell cycle, promoting processes like endoreduplication and preventing normal cytokinesis. This manipulation is essential for the induction of the massive, multinucleate feeding cells required for the parasite's nutrition and reproductive success.

281. (B) Facilitate penetration and expansion of cells
Nematodes have evolved to secrete expansin-like proteins that mimic the function of natural plant expansins, which loosen cell wall structures. By secreting these mimics, the nematode can facilitate its own penetration through the root tissue and promote the rapid expansion of the host cells at the feeding site. This structural manipulation is crucial for the successful establishment of a nutrient-rich feeding site.

282. (B) Horizontal gene transfer from bacteria or fungi
The presence of genes encoding plant-like cell-wall-degrading enzymes (CWDEs) in nematode genomes is widely attributed to horizontal gene transfer from soil-dwelling bacteria or fungi. This evolutionary event provided nematodes with the tools necessary to breach complex plant barriers, a capability that was a prerequisite for the development of plant parasitism. This acquisition highlights the important role of gene transfer.

283. (A) Alter the plant's pathway to reduce defenses
Chorismate mutase is a nematode effector that mimics a plant enzyme to manipulate the shikimate pathway. By increasing the flux toward other aromatic amino acids and away from chorismate, the nematode effectively reduces the production of salicylic acid, a critical defense signaling molecule. This molecular mimicry allows the parasite to suppress the host's immune response and ensure a compatible interaction.

284. (B) Directly reprogram host gene expression
Some nematode effectors are designed to mimic plant transcription factors. Once delivered into the host cell nucleus, these mimics can bind to specific DNA sequences and directly reprogram host gene expression to favor the nematode's needs. This high-level manipulation allows the parasite to coordinate the complex physiological and structural changes required to transform a root cell into a specialized feeding site.

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248. (B) Failure of gall formation and development
Disruption of the normal transport and accumulation of auxin in the root using chemical inhibitors like NPA typically leads to the failure of gall formation and development. Since the localized accumulation of auxin is the primary driver of the abnormal cell division and expansion required for galling, blocking its movement prevents the nematode from successfully manipulating the host's root tissue.

249. (A) Salicylic acid (SA)
The salicylic acid (SA) pathway is classically associated with systemic defense signaling against biotrophic pathogens, including sedentary nematodes during their initial infection stages. SA plays a key role in triggering the hypersensitive response and establishing systemic acquired resistance throughout the plant. Successful nematodes often produce effectors that specifically target and suppress this pathway to avoid detection and host defense.

250. (B) Necrotrophic pathogens and chewing insects
Jasmonic acid (JA) signaling is a major plant defense pathway that is primarily involved in protecting against necrotrophic pathogens, which feed on dead tissue, and chewing insects. While it also plays a role in some nematode interactions, particularly with migratory species that cause extensive tissue damage, it is distinct from the SA pathway that typically responds to biotrophic parasites.

251. (B) They suppress SA to prevent defense activation
During a compatible interaction, nematode effectors actively suppress the host plant's salicylic acid (SA) pathways to prevent the activation of effective defense responses. By lowering SA levels or interfering with its signaling, the nematode avoids the triggering of the hypersensitive response and systemic acquired resistance. This suppression is a key strategy for maintaining a living and productive feeding site.

252. (B) Localized accumulation of auxin and ethylene
The localized swelling seen in root galls is the result of a combination of increased cell division and cell expansion. These processes are primarily driven by the accumulation of auxin and ethylene at the infection site. These hormones work together to reprogram the growth and development of the cortical cells, leading to the characteristic macroscopic symptoms of root-knot nematode infection.

253. (B) Antimicrobial compounds synthesized de novo
Phytoalexins are defined as low-molecular-weight antimicrobial compounds that are synthesized de novo by the plant in response to infection or stress. Unlike constitutive defenses, they are not present in the healthy plant but are produced rapidly after a pathogen or nematode is recognized. These chemicals can be toxic to the parasite, contributing to the host's induced biochemical resistance.

254. (C) Soybean
Glyceollin is a well-known phytoalexin produced by soybean (Glycine max) in response to infection by the soybean cyst nematode, Heterodera glycines. The accumulation of glyceollin at the infection site is a characteristic feature of a resistant response. This compound can inhibit the growth and development of the nematode, playing an important role in the plant's induced biochemical defense response.

255. (C) Cotton
Gossypol is a terpenoid compound that is primarily associated with cotton plants. It accumulates in specialized pigment glands throughout the plant, including the roots, and acts as a potent toxin against various pests and pathogens. In the context of nematology, gossypol has been shown to contribute to resistance against root-knot and other nematode species by deterring feeding and reproduction.

256. (B) Act as precursors and oxidize into toxic quinones
The rapid accumulation of phenolic compounds in cells adjacent to a migrating nematode is a key defensive strategy. These phenolics act as precursors that can be rapidly oxidized by enzymes into toxic quinone compounds. These quinones are highly reactive and can directly inhibit the nematode or contribute to the localized cell death (HR) that halts the parasite's progress through the root.

257. (B) In large quantities following pathogen recognition
Pathogenesis-related (PR) proteins are a diverse group of proteins that are typically produced by

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This indirect recognition allows plants to detect effectors.

199. (C) Selection for nematodes lacking the Avr gene
When a nematode population is repeatedly exposed to a host with a single major R gene, strong selection pressure favors any individuals that have lost or mutated the corresponding avirulence (Avr) gene. These "virulent" individuals are not recognized by the plant and can reproduce freely. Over time, they will dominate the population, leading to the breakdown of the resistance.

200. (C) A is true but R is false
While it is true that gene-for-gene resistance often results in a hypersensitive response (HR), the assertion that HR is a universal baseline defense in all plants regardless of R gene presence is false. HR is a specific, high-level defense triggered by the recognition of effectors through R genes. It is not always present and is distinct from basal defenses.

201. (B) Avirulence (Avr) protein
A nematode effector that is specifically recognized by a corresponding plant resistance (R) gene product is termed an avirulence (Avr) protein. This recognition is the molecular basis of the gene-for-gene interaction. The term is somewhat paradoxical because the protein itself often functions as a virulence factor in susceptible hosts where the matching R gene is absent and recognition fails.

202. (C) R gene-mediated resistance
Effector-Triggered Immunity (ETI) is a term used in modern plant pathology that is largely synonymous with R gene-mediated resistance. It refers to the highly specific immune response that is triggered when a plant's resistance protein recognizes a specific pathogen effector. ETI is often characterized by a rapid hypersensitive response and provides a strong, qualitative level of resistance against parasites.

203. (B) Conserved signatures like cuticular components
PAMP-Triggered Immunity (PTI) is the plant's first line of active defense and is triggered by the recognition of conserved molecular signatures known as pathogen-associated molecular patterns (PAMPs). In nematodes, these might include common components of the cuticle or conserved proteins that are essential for the parasite's biology. Unlike ETI, which is highly specific, PTI provides a broader, basal defense.

204. (B) To prevent basal defense from halting infection
Successful nematodes must secrete effectors that specifically suppress PAMP-triggered immunity (PTI) to prevent this basal defense from halting the infection process. If the plant's initial immune response is not repressed, it could prevent the nematode from establishing a feeding site or lead to its starvation. This active suppression of PTI is a critical requirement for a compatible interaction.

205. (C) Solanum peruvianum (Wild tomato)
The Mi-1 gene, the first nematode resistance gene to be successfully cloned, was originally discovered in Solanum peruvianum, a wild relative of the cultivated tomato. It was introduced into commercial tomato varieties through interspecific crosses to provide resistance against several major species of root-knot nematodes. This gene has been a cornerstone of nematode management in tomato production for decades.

206. (D) Both potato aphid and specific whiteflies
The Mi-1.2 gene is remarkable because it confers resistance not only to several species of root-knot nematodes but also to specific insect pests, including the potato aphid and certain biotypes of whiteflies. This dual-purpose resistance is highly unusual and suggests that the gene targets a signaling pathway or a cellular component that is essential for both nematodes and these insects.

NODIA

207. (C) Fails at soil temperatures above 28°C
A significant and well-known limitation of the resistance provided by the Mi-1 gene in tomato is its temperature sensitivity. The resistance becomes ineffective when soil temperatures consistently rise above 28°C. In such conditions, the plant becomes susceptible, and the nematodes can successfully infect and reproduce. This limitation is a major concern for growers in hot climates and greenhouses.

208. (A) P-4, Q-3, R-1, S-2
Mi-1 targets Meloidogyne species, while Hs1pro-1 provides resistance against Heterodera schachtii. Gpa2 is effective against Globodera pallida, and Hero A provides broad resistance to both species of Globodera. This matching correctly

the activation of various post-infectional defense pathways within the cell.

267. (B) IT acts as a toxin and signaling molecule
Hydrogen peroxide (H2O2) plays a crucial dual role during the plant's resistance response to nematodes. It acts as a direct toxin that can damage the parasite's tissues and as a powerful signaling molecule that triggers the activation of defense genes and the cross-linking of cell wall polymers. This multifunctionality makes ROS a central component of induced plant immunity.

268. (B) NADPH oxidase (RBOH)
The enzyme primarily responsible for the rapid generation of superoxide radicals during the oxidative burst is NADPH oxidase, often referred to as Respiratory Burst Oxidase Homolog (RBOH) in plants. This enzyme, located in the plasma membrane, transfers electrons from NADPH to molecular oxygen to produce the reactive superoxide radical. This is the first step in the ROS signaling cascade.

269. (B) Utilizing H2O2 to catalyze cell wall cross-linking
Peroxidase enzymes play a critical role in host defense by utilizing hydrogen peroxide to catalyze the cross-linking of structural polymers in the plant cell wall, such as lignin and extensins. This process, known as wall reinforcement, makes the cell wall much more resistant to the mechanical force and enzymatic degradation used by the nematode during penetration and feeding.

270. (A) Oxidizing phenolic compounds into toxic quinones
Polyphenol oxidase (PPO) contributes to nematode resistance by oxidizing phenolic compounds into highly reactive and toxic quinones. These quinones can directly inhibit the nematode's enzymes and contribute to the rapid cell death (HR) that starves the parasite. The activity of PPO is responsible for the characteristic browning seen in the roots of many resistant plant varieties following infection and detection.

271. (C) THE phenylpropanoid pathway for phenolics
Phenylalanine ammonia-lyase (PAL) is a crucial regulatory enzyme because it controls the first committed step in the phenylpropanoid pathway. This metabolic pathway is responsible for the synthesis of a wide range of important phenolic compounds, including lignin, flavonoids, and certain phytoalexins. The activation of PAL is a key indicator that the plant is shifting its metabolism toward active defense.

272. (B) THE activation of biochemical defense mechanisms
The rapid upregulation of phenylalanine ammonia-lyase (PAL) activity following nematode infection is a strong molecular indicator of the activation of the plant's biochemical defense mechanisms. By increasing the flux through the phenylpropanoid pathway, the plant produces the phenolics and lignin necessary for structural reinforcement and chemical toxicity. This response is a hallmark of an induced and active resistance.

273. (D) I, II and III
Peroxidase, polyphenol oxidase (PPO), and phenylalanine ammonia-lyase (PAL) are all critical enzymes in the plant's biochemical defense response against nematodes. They work together to produce toxic compounds, reinforce cell walls, and initiate the hypersensitive response. The coordinated activation of these three enzymes is a common feature of resistant interactions and is essential for successfully halting the parasite.

274. (B) ROS-scavenging enzymes such as peroxiredoxins
Successful nematodes have evolved strategies to protect themselves from the toxic effects of the plant's oxidative burst. They secrete a variety of ROS-scavenging enzymes, such as peroxiredoxins and glutathione peroxidases, into the host tissue. These enzymes neutralize the reactive oxygen species produced by the plant, allowing the nematode to survive and continue the infection process despite the host's active immune response.

275. (B) Superoxide radicals into peroxide and oxygen
Superoxide dismutase (SOD) is an important antioxidant enzyme that acts by catalyzing the conversion of highly reactive superoxide radicals into less harmful hydrogen peroxide and molecular oxygen. While plants use SOD to regulate their own ROS signaling, nematodes also produce and secrete their own SOD enzymes to detoxify the host's oxidative burst, thereby protecting their tissues from damage.

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high osmotic pressure needed to drive nutrient influx.

239. (C) Ethylene and Abscisic acid (ABA)
Premature leaf senescence in nematode-infected plants is hormonally linked to an increase in the production of ethylene and abscisic acid (ABA). These stress-related hormones are upregulated in response to the root damage and the resulting water and nutrient deficiencies. Their accumulation in the foliage triggers the organized breakdown of chlorophyll and other cellular components, leading to early leaf death.

240. (B) Drives the influx of water and nutrients
The localized accumulation of sugars and other solutes within a feeding site creates a high internal osmotic pressure. This pressure is essential because it drives the continuous influx of water and nutrients from the surrounding host tissues. This osmotic gradient ensures that the feeding site remains a powerful metabolic sink, capable of providing the parasite with a steady nutrient supply.

241. (A) Auxin (IAA)
The formation of root galls by Meloidogyne requires the localized accumulation of the plant hormone auxin, specifically indole-3-acetic acid (IAA). Auxin is a key regulator of cell division and expansion. By manipulating auxin levels at the infection site, the nematode triggers the rapid and abnormal growth of cortical cells that results in the characteristic macroscopic galling seen on roots.

242. (B) By altering plant PIN efflux carrier proteins
Root-knot nematodes manipulate host auxin gradients by interfering with the plant's PIN efflux carrier proteins, which are responsible for the directional transport of auxin. By altering the localization and activity of these carriers, the nematode can cause auxin to accumulate specifically at the infection site. This localized high concentration of hormone is what drives the initiation and growth of galls.

243. (B) Stimulate the cell cycle and acytokinetic mitosis
High levels of cytokinins are essential during the early stages of giant cell formation because they stimulate the host cell cycle and promote acytokinetic mitosis. Cytokinins work in tandem with auxin to drive the repeated nuclear divisions without cytokinesis that characterize these specialized feeding sites. This hormonal manipulation is a fundamental step in the nematode's ability to reprogram plant development.

244. (B) Cytokinin
Some plant-parasitic nematodes have been shown to secrete molecules that act as mimics of plant cytokinins. By delivering these mimics into the host cell, the nematode can directly promote cell division and maintain the metabolic activity of its feeding site. This molecular mimicry allows the parasite to bypass the plant's normal hormonal regulation and ensure a stable nutrient source for development.

245. (B) IT promotes tissue softening and radial expansion
Ethylene production is often upregulated during the initial stages of nematode penetration and infection. This hormone primarily plays a role in promoting tissue softening and the radial expansion of cells at the infection site. These changes can facilitate the movement of the nematode through the root and contribute to the overall swelling associated with gall and syncytium development.

246. (B) Auxin and Cytokinin
The precise balance between auxin and cytokinin is absolutely critical for the induction and long-term maintenance of specialized feeding cells like giant cells and syncytia. These two hormones work together to coordinate the complex changes in the cell cycle, cell wall structure, and metabolic activity that transform normal root tissue into a functional nutrient sink for the parasite.

247. (A) Both A and R are true and R is the correct explanation of A
Root-knot and cyst nematodes secrete CLE-like peptides that mimic endogenous plant signaling molecules. These peptides are recognized by the plant's own receptor kinases that normally regulate the maintenance of stem cell populations in meristems. By hijacking this system, the nematode can manipulate host developmental pathways to promote the formation and expansion of its specialized feeding site in the root.

NODIA

285. (C) Nucleus
A nematode effector that contains a nuclear localization signal (NLS) is specifically designed to be transported into the host cell's nucleus. This destination is critical for effectors that function by directly interacting with the host's DNA or transcription factors. By entering the nucleus, these molecules can reprogram the plant's gene expression to support the establishment and maintenance of the feeding structure.

286. (D) III
Molecular mimicry is a strategy used by biotrophic parasites like sedentary nematodes to manipulate host biology while keeping the host cells alive. Therefore, the statement that it always results in the immediate death of the host cell is incorrect. Instead, successful mimicry allows the nematode to hijack host signaling pathways (such as through CLE-like peptides) to create a productive feeding environment.

287. (B) Keep the plant's immune system repressed
Nematode secretions can contain mimics of plant defense suppressors, which function to keep the host's immune system in a repressed state. By delivering these molecules, the parasite prevents the activation of defense genes and the initiation of responses like the hypersensitive response. This active maintenance of a suppressed state is essential for the long-term survival of biotrophic parasites within the root.

288. (B) Sophisticated biotrophic engineers of host tissue
The presence of functional mimicry effectors provides strong evidence that sedentary plant-parasitic nematodes are far more than simple mechanical destructive agents. Instead, they act as sophisticated biotrophic engineers of host tissue. By hijacking endogenous plant signaling and developmental pathways, they actively transform normal root cells into highly specialized feeding structures that are essential for their own growth and high reproduction.

289. (B) Cellular metabolism and transport genes
Transcriptomic studies of compatible interactions in susceptible hosts typically reveal a massive upregulation of plant genes involved in cellular metabolism and transport. This reflects the transformation of the root cells into specialized sinks that are actively providing nutrients to the nematode. In these cases, the plant's own resources are redirected to support the parasite's high metabolic and energy demands.

290. (B) Defense-related genes like PR and WRKY
In contrast to susceptible hosts, transcriptomic profiling of an incompatible or resistant interaction reveals the rapid and massive upregulation of defense-related genes, such as those encoding pathogenesis-related (PR) proteins and WRKY transcription factors. This shift occurs within hours of infection and is responsible for triggering the hypersensitive response and other active defenses that successfully halt the nematode's progress.

291. (B) Selection for mutations in effector genes
When a nematode population is repeatedly exposed to a resistant cultivar, the most significant genomic shifts involve selection for mutations in specific effector genes. Individuals with mutations that allow them to avoid recognition by the plant's resistance protein will survive and reproduce. This directional selection leads to the emergence of virulent pathotypes and the eventual breakdown of the host's resistance.

292. (B) Protein synthesis and metabolic turnover
Proteomic analysis of giant cells reveals a significant increase in proteins associated with protein synthesis, protein folding, and overall metabolic turnover. This profile is consistent with the intense metabolic activity required to function as a dedicated nutrient transfer cell. The abundance of these proteins supports the rapid production of the enzymes and transporters necessary to maintain the feeding site.

293. (B) Post-transcriptional regulation of gene expression
Small RNAs (sRNAs), including microRNAs, play a critical role in the dynamic regulation of gene expression during nematode infection. They function as post-transcriptional regulators that can silence specific host genes to favor the establishment of the feeding site. The shifting profiles of sRNAs in both the host and the parasite reflect the complex molecular dialogue that occurs during parasitism.

294. (B) THE transcriptomes of both host and parasite
Dual RNA-seq is a powerful technology that allows for the simultaneous transcriptomic profiling of both the host plant and the invading

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region.
(C) It is connected to the renette cell or tubular system.
(D) It functions in both osmoregulation and secretion.

2025

54. Active ion transport mechanisms in the nematode hypodermis lead directly to:
(A) Paralysis of somatic muscles
(B) Reduction of internal hydrostatic pressure
(C) Maintenance of appropriate pseudocoelomic ionic concentrations
(D) Synthesis of structural cuticlins

2010

55. Select the correct sequence of events when a nematode enters a hyperosmotic environment:
(A) Water efflux → Shrinkage → Solute synthesis → Volume recovery
(B) Solute synthesis → Water efflux → Shrinkage → Volume recovery
(C) Volume recovery → Shrinkage → Water efflux → Solute synthesis
(D) Shrinkage → Volume recovery → Water efflux → Solute synthesis

2016

56. Which molecule is NOT typically used as a compatible solute for osmoregulation in nematodes?
(A) Trehalose
(B) Glycerol
(C) Proline
(D) Free fatty acids

2024

57. Identify the correct pair regarding solute adaptation:
(A) Hypotonic stress - Synthesis of trehalose
(B) Hypertonic stress - Accumulation of compatible osmolytes
(C) Isotonic environment - Massive water excretion
(D) Anhydrobiosis - Elimination of all internal sugars

2022

58. Classification of nematode osmoregulatory strategy in fluctuating soil environments:
(A) Strict osmoconformers
(B) Impermeable isolators
(C) Euryhaline osmoregulators
(D) Stenohaline osmoconformers

2017

59. Physiological adaptations to varying soil solutes include all EXCEPT:
(A) Behavioral avoidance of extreme gradients
(B) Modulation of excretory pulsation rate
(C) Alteration of cuticular permeability
(D) Activation of flame cells

2007

60. Read the following statements regarding the pathway of fluid in a tubular excretory system:
(A) Excretory pore → Canal → Secretory cell → Pseudocoelom
(B) Pseudocoelom → Canal → Excretory duct → Excretory pore
(C) Pseudocoelom → Intestine → Excretory pore → Canal
(D) Excretory duct → Pseudocoelom → Canal → Excretory pore

NODIA

2015

61. Structural variation defining the Secernentean (Chromadorean) secretory-excretory (SE) system:
(A) A single glandular renette cell without canals
(B) A complex H-shaped tubular system
(C) Protonephridia with flame cells
(D) Malpighian tubules

2021

62. The term "renette cell" refers to:
(A) A specialized sensory neuron in the amphid
(B) A large ventral glandular cell involved in excretion/secretion
(C) The absorptive cell of the intestinal epithelium
(D) A muscle cell associated with the vulva

2018

63. Correct statement regarding the H-shaped excretory system:
(A) It consists of longitudinal canals embedded in the lateral hypodermal chords.
(B) It completely lacks a transverse commissure.
(C) It is the primary site of gamete production.
(D) It empties through a dorsal pore.

2009

64. Identify the INCORRECT statement about the physiological roles of the SE system:
(A) It secretes the glycoprotein surface coat in some species.
(B) It removes excess water in hypotonic environments.
(C) It is responsible for the phagocytosis of invading bacteria.

CHAPTER 06
Nematode Physiology and Cytology

2024

1. Primary biochemical component constituting the basal layer of the nematode cuticle:
(A) Cuticlin
(B) Chitin
(C) Keratin
(D) Collagen

2017

2. Functional role of surface coat glycoconjugates in parasitic nematodes:
(A) Providing structural rigidity
(B) Digestion of plant cell walls
(C) Evasion of host immune responses
(D) Long-term storage of lipids

2015

3. Correct statement regarding cuticlins in the nematode exoskeleton:
(A) They are soluble proteins easily degraded by enzymatic proteases.
(B) They form cross-linked, non-collagenous structural networks.
(C) They are exclusively localized within the fluid pseudocoelom.
(D) They catalyze the synthesis of the neurotransmitter acetylcholine.

2001

4. Identify the INCORRECT statement about the nematode cuticle structure:
(A) It acts as a hydrostatic skeleton antagonist.
(B) It is secreted by the underlying hypodermis.
(C) It restricts unlimited radial expansion.
(D) It is composed mainly of living, nucleated cells.

2002

5. Identify the correct pair regarding cuticle layers and properties:
(A) Median layer - Struts and fluid-filled spaces in some species
(B) Epicuticle - Rich in non-collagenous cuticlins
(C) Basal layer - Contains surface glycoconjugates
(D) Cortical layer - Composed of fluid lipids

2005

6. Which of the following is rarely a major structural component of the nematode cuticle?
(A) Glycoproteins
(B) Collagens
(C) Chitin
(D) Cuticlins

2025

7. If a mutation disrupts collagen cross-linking in a nematode, the most likely immediate physical consequence is:
(A) Loss of cuticular elasticity and hydrostatic integrity
(B) Failure to synthesize trehalose
(C) Overproduction of surface glycoconjugates
(D) Premature hatching of eggs

2023

8. Extensive disulfide bonding in cuticular collagens leads directly to:
(A) Increased flexibility and solubility
(B) Rapid degradation during moulting
(C) Inhibition of hypodermal secretion
(D) Enhanced mechanical strength and resistance

NODIA

2010

9. Classification of the nematode cuticle based on origin and tissue type:
(A) Mesodermal living tissue
(B) Ectodermal non-cellular secretion
(C) Endodermal fluid layer
(D) Ectodermal nucleated epithelium

2021

10. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): The nematode cuticle is a metabolically inert structure.
Reason (R): It is periodically shed and replaced during the moulting process to allow growth.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

(D) Independent movement of the digestive tract

2017

33. Classification of nematode somatic muscles based on functional mechanics:
(A) Exclusively circular
(B) Both circular and longitudinal
(C) Helical and diagonal
(D) Exclusively longitudinal

2006

34. Which of the following is NOT a component of a nematode somatic muscle cell?
(A) Contractile fibrillar zone
(B) Non-contractile sarcoplasmic belly
(C) Intercalated disc
(D) Innervation process (muscle arm)

2009

35. Read the following statements regarding somatic muscle cell types:
I. Platymyarian cells have fibrillar zones adjacent only to the hypodermis.
II. Coelomyarian cells have fibrillar zones extending up the sides of the cell.
III. Circomyarian cells completely enclose the sarcoplasm with fibrils.
IV. Polymyarian refers to cell shape rather than number.
Which of the above statements are INCORRECT?
(A) I, II and III
(B) II and III
(C) I and IV
(D) IV

2013

36. Most appropriate reason why large parasitic nematodes exhibit polymyarian muscle arrangements:
(A) It reduces the reliance on a primary hydrostatic skeleton.
(B) It eliminates the requirement for longitudinal nerve cords.
(C) It facilitates the rapid entry into cryptobiotic states.
(D) It provides greater force for movement in dense host tissues.

2021

37. Biochemical composition primarily characterizing the pseudocoelomic fluid:
(A) Aqueous solution of proteins, metabolites, and inorganic ions
(B) Hemolymph rich in respiratory pigments
(C) Pure distilled water
(D) Dense lipid emulsion

2003

38. The principal biomechanical role of the pseudocoelomic fluid is to function as a:
(A) Digestive enzyme reservoir
(B) Site of gamete production
(C) Hydrostatic skeleton
(D) Locomotory appendage

2010

39. Identify the INCORRECT statement about the pseudocoelom:
(A) It is completely lined by mesodermal epithelium.
(B) It facilitates the transport of nutrients and waste.
(C) It maintains a high internal hydrostatic pressure.
(D) It lacks an independent circulatory pumping organ.

2013

40. Read the following statements regarding pseudocoelomic pressure maintenance:
I. The cuticle provides structural resistance.
II. Somatic muscles contract against the fluid.
III. The intestine actively pumps fluid out of the body.
IV. Fluid volume is regulated by the excretory system.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) I and III
(D) II and III

2001

41. Identify the correct pair regarding pseudocoelomic fluid constituents:
(A) Hemoglobin - Present in all plant-parasitic nematodes
(B) Trehalose - Circulates to provide systemic stress protection
(C) Ascarosides - Maintained exclusively in the pseudocoelom
(D) Cellulases - Stored in the fluid for extracellular digestion

2009

42. If a nematode's pseudocoelomic membrane is punctured, the most immediate functional loss is:
(A) Inability to synthesize lipids
(B) Immediate cessation of egg production
(C) Loss of structural turgor and locomotory failure
(D) Hyperactivation of the nervous system

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2025

22. Classification of trehalose biochemically:
(A) Beta-linked polysaccharide
(B) Amino sugar
(C) Alpha-linked disaccharide of glucose
(D) Glycoconjugate

2008

23. Which enzyme is NOT directly involved in the mobilization of primary nematode energy reserves?
(A) Cellulase
(B) Lipase
(C) Glycogen phosphorylase
(D) Trehalase

2015

24. Most appropriate adaptive advantage of utilizing lipids as the primary energy reserve:
(A) Lipids yield more water upon oxidation than carbohydrates.
(B) Lipids are easier to transport in the pseudocoelom.
(C) Lipids can function as neurotransmitters.
(D) Lipids provide the highest energy yield per unit mass.

2005

25. Definition of a holomyarian somatic muscle arrangement:
(A) Two to five muscle cells per quadrant
(B) A continuous layer of numerous small muscle cells
(C) Muscle cells lacking striations entirely
(D) Muscle cells forming circular bands

2022

26. The distinctive feature of nematode neuromuscular junctions is that:
(A) Nerve axons branch out to synapse on muscle fibers.
(B) Synapses occur randomly in the pseudocoelom.
(C) Muscle arms extend to the nerve cords to form synapses.
(D) Gap junctions directly connect hypodermis to nerves.

2022

27. Correct statement regarding meromyarian muscle architecture:
(A) It contains dozens of specialized cells per quadrant.
(B) It is characteristic of large animal-parasitic nematodes.
(C) It lacks active actin and myosin contractile filaments.
(D) It features two to five large muscle cells per quadrant.

2006

28. Identify the INCORRECT statement about nematode somatic muscle cells:
(A) They are arranged in circular layers around the intestine.
(B) They are obliquely striated.
(C) They consist of a contractile spindle and a non-contractile belly.
(D) They extend muscle arms to the dorsal or ventral nerve cords.

NODIA

2012

29. Identify the correct pair of muscle classification and its feature:
(A) Holomyarian - Few flat cells
(B) Polymyarian - Numerous cells per quadrant projecting into the pseudocoelom
(C) Meromyarian - Continuous unbroken muscle ring
(D) Platymyarian - Cells lacking a non-contractile portion

2010

30. Read the following statements regarding nematode muscle architecture:
I. Polymyarian nematodes have many cells per quadrant.
II. Meromyarian nematodes have 2-5 cells per quadrant.
III. All nematode somatic muscles are cross-striated.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I
(D) III

2016

31. If a chemical competitively blocks acetylcholine receptors on the muscle arms, the result is:
(A) Flaccid paralysis of the somatic muscles
(B) Continuous tetanic contraction
(C) Hyperactive undulatory movement
(D) Immediate initiation of moulting

2014

32. The obliquely striated nature of nematode muscles allows for:
(A) Multi-directional appendage movement
(B) Rapid circular constrictions of the body wall
(C) Smoother and more graded longitudinal contractions

nematode from the same infected tissue sample. This approach provides a comprehensive view of the molecular interactions and the synchronized gene expression shifts that occur in both organisms throughout the infection process. It is essential for understanding complex parasitism.

295. (B) Sugars, amino acids, and organic acids
Metabolomic profiling of root-knot nematode galls typically reveals a massive localized accumulation of primary metabolites, including sugars, amino acids, and organic acids. These compounds are imported from the rest of the plant to support the high energy and nutritional demands of the sedentary female. This profile confirms the feeding site's role as a dominant and efficient metabolic sink.

296. (B) Transcriptional reprogramming for the feeding site
Epigenetic shifts, such as changes in DNA methylation and histone modification in the host genome, play a significant role in the transcriptional reprogramming required to form a feeding site. These modifications can lead to the long-term activation or silencing of specific sets of genes without altering the underlying DNA sequence. This epigenetic control is essential for maintaining site function.

297. (B) Identifying the effector proteins injected
Proteomic analysis of the nematode secretome, which includes all proteins secreted by the parasite, has been crucial for identifying the specific effector proteins injected into host cells. By understanding the composition of the secretome, researchers can pinpoint the molecular tools that nematodes use to suppress plant immunity and manipulate host development. This knowledge is fundamental for developing resistance.

298. (B) Plant transcription factors regulating defense
WRKY genes encode a large family of plant-specific transcription factors that play a central role in regulating the immune response. Their rapid activation in resistant interactions is a key step in triggering the expression of many other defense-related genes. By coordinating the plant's response to nematode attack, WRKY factors are essential for the successful execution of an induced resistance.

299. (A) II, III and V
Omics research shows that resistant interactions are characterized by rapid HR-related transcripts, and dual RNA-seq can profile both host and parasite simultaneously. Furthermore, the secretome consists of proteins delivered by the nematode into the host. However, susceptible interactions typically show an initial suppression rather than a continuous upregulation of defense genes, and giant cells have highly upregulated pathways.

300. (C) Identify molecular targets for resistant crops
The ultimate goal of comparative omics in plant nematology is to identify the specific molecular targets and pathways that distinguish susceptible and resistant interactions. By understanding these differences, researchers can discover new sources of resistance and develop targeted strategies for crop improvement. This information is essential for breeding the next generation of resistant varieties and ensuring agricultural sustainability.

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2022

43. The high hydrostatic pressure within the pseudocoelom requires that the digestive tract:
(A) Relies on ciliary action for food transport
(B) Remains completely open at all times
(C) Secretes highly acidic fluid to lower internal pressure
(D) Possesses a muscular pharynx to pump food inwards

2025

44. Which physiological process is LEAST dependent on the pseudocoelomic fluid?
(A) Direct perception of environmental chemical signals
(B) Distribution of absorbed nutrients
(C) Maintenance of body shape
(D) Transfer of mechanical force during movement

2017

45. Read the following statements regarding the roles of pseudocoelomic fluid:
I. Acts as a lubricant for internal organs
II. Transports endocrine signaling molecules
III. Facilitates gas exchange in the absence of a respiratory system
IV. Synthesizes cuticular collagens
V. Buffers rapid changes in external osmolarity
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, II, III and V
(C) II, III and IV
(D) III, IV and V

2007

46. Classification of the pseudocoelom morphologically:
(A) True coelom
(B) Blastocoel-derived cavity lacking complete mesodermal lining
(C) Acoelomate solid tissue
(D) Schizocoelous cavity

2002

47. The pseudocoelomic fluid contains all of the following EXCEPT:
(A) Erythrocytes
(B) Amino acids
(C) Organic acids
(D) Inorganic cations

2013

48. Most appropriate reason why pseudocoelomic transport is relatively fast:
(A) Ciliated epithelia drive fluid circulation.
(B) A dorsal heart continuously pumps the fluid.
(C) Continuous body movements thoroughly mix the internal fluids.
(D) Osmotic gradients actively propel fluid unidirectionally.

2008

49. Mechanism of osmoregulation in nematodes facing hypotonic soil environments:
(A) Active uptake of water through the cuticle
(B) Synthesis of massive intracellular lipid stores
(C) Complete closure of the mouth and anus
(D) Rapid excretion of excess water via the excretory system

2004

50. Correct statement about nematode adaptation to hypertonic soil solutions:
(A) They rapidly excrete water to match the soil.
(B) They actively transport salt into the pseudocoelom.
(C) They accumulate compatible solutes like glycerol and trehalose to balance osmolarity.
(D) They replace their cuticle with an impermeable chitin layer.

2016

51. Read the following statements regarding osmoregulatory organs:
I. The renette cell functions in osmoregulation.
II. The intestine plays a role in ion balance.
III. The amphids actively pump out excess water.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) III
(D) I

2008

52. When a nematode is transferred from wet soil to a drying, high-salinity environment, its initial physiological response is:
(A) Rapid swelling and lysis
(B) Immediate moulting to a smaller size
(C) Shedding of the intestinal lining
(D) Shrinkage followed by intracellular accumulation of osmoprotectants

2015

53. Identify the INCORRECT statement regarding the excretory-secretory (ES) pore:
(A) It serves as the primary exit for solid digestive waste.
(B) It is usually located ventrally in the anterior

NODIA

(D) A is false but R is true.

2021

11. All are structural adaptations of the cuticle EXCEPT:
(A) Annulations for flexibility
(B) Longitudinal alae for locomotion
(C) Strutted median zones for structural support
(D) Microvilli for nutrient absorption

2022

12. Most appropriate description of the surface coat's origin:
(A) Continuously secreted by glandular cells and hypodermis
(B) Synthesized by intestinal cells and exported
(C) Absorbed directly from the host environment
(D) Formed from degraded cuticular collagens

2019

13. Primary energy reserve molecule utilized during prolonged starvation in nematodes:
(A) Protein
(B) Lipid
(C) Glycogen
(D) Chitin

2002

14. The principal site for lipid storage in non-parasitic nematodes is the:
(A) Cuticle
(B) Intestinal epithelium
(C) Nerve ring
(D) Excretory pore

2003

15. Correct statement concerning glycogen storage in nematodes:
(A) It provides readily mobilizable energy for muscle contraction.
(B) It is solely stored in the amphids.
(C) It is the primary energy source during anhydrobiosis.
(D) It cannot be synthesized from lipid precursors.

2009

16. Identify the INCORRECT statement about trehalose metabolism in nematodes:
(A) Trehalose protects cellular membranes during desiccation.
(B) Trehalose is synthesized from glucose.
(C) Trehalose is a reducing sugar that quickly reacts with proteins.
(D) Trehalose levels spike during environmental stress.

2012

17. Identify the correct pair regarding energy reserves and function:
(A) Lipids - Rapid short-term energy spikes
(B) Trehalose - Structural component of the eggshell
(C) Proteins - Main energy reserve in dauer larvae
(D) Glycogen - Immediate energy for somatic muscles

2005

18. Which metabolic pathway is NOT typically used for energy reserve utilization in aerobic nematodes?
(A) Beta-oxidation
(B) Glycolysis
(C) Fermentation to ethanol
(D) Tricarboxylic acid cycle

2015

19. An increase in trehalose-6-phosphate synthase activity indicates the nematode is likely preparing for:
(A) Rapid reproduction
(B) Cryptobiotic survival
(C) Moulting
(D) Digestion of a new host

2006

20. Match the energy component (List I) to its characteristic (List II):
List I: (Energy Component)
P. Lipid
Q. Glycogen
R. Trehalose
S. Glucose
List II: (Characteristic)
1. Non-reducing stress protectant
2. Monosaccharide intermediate
3. Main long-term storage
4. Branched polymer in muscle
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2007

21. The conversion of lipids to carbohydrates via the glyoxylate cycle allows nematodes to:
(A) Form trehalose from fat stores during embryogenesis
(B) Synthesize essential amino acids
(C) Digest host cell walls more efficiently
(D) Increase body size without moulting

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(D) It synthesizes digestive cellulases in plant-parasitic nematodes.

2012

65. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): The H-shaped tubular system is considered evolutionarily advanced compared to the single renette cell.
Reason (R): It provides a larger surface area for fluid collection and regulation in terrestrial and parasitic habitats.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

66. Identify the correct pair regarding SE system components:
(A) Excretory sinus - Connects the two longitudinal canals
(B) Lateral chords - House the ventral nerve cord
(C) Excretory duct - Lined with cuticle
(D) Excretory gland - Primary organ of locomotion

2004

67. If the transverse canal of an H-shaped system is blocked, the immediate effect is:
(A) Enhanced reproductive output
(B) Inability of fluid from one longitudinal canal to reach the excretory duct
(C) Complete loss of sensory perception
(D) Increased digestion of host plant tissues

2015

68. The presence of a cuticular lining in the terminal excretory duct ensures:
(A) Absorption of water from the environment
(B) Synthesis of cuticular collagens
(C) Continuous entry of pseudocoelomic fluid
(D) Structural integrity during high-pressure fluid expulsion

2009

69. The secretory-excretory system in nematodes does NOT function in:
(A) Exchange of respiratory gases
(B) Osmoregulation
(C) Secretion of mucins
(D) Excretion of some metabolic wastes

2023

70. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Secernentean nematodes generally possess a more complex tubular excretory system than Enoplean nematodes.
Reason (R): Tubular systems provide a larger surface area for collection and regulation of internal fluids.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2018

71. Classification of the renette cell based on morphology:
(A) Unicellular ventral gland
(B) Multicellular syncytium
(C) Tubular network
(D) Ciliated epithelium

2019

72. Most appropriate function of the secretory granules found in the SE system of animal-parasitic nematodes:
(A) Digesting host cell walls
(B) Solidifying the eggshell
(C) Inducing anhydrobiosis
(D) Releasing immunomodulatory compounds into the host

2002

73. Primary nitrogenous waste product excreted by aquatic nematodes:
(A) Uric acid
(B) Ammonia
(C) Urea
(D) Guanine

2010

74. The excretion of ammonia is highly advantageous for aquatic nematodes because:
(A) It requires significant energy to synthesize.
(B) It is non-toxic to internal tissues at high concentrations.
(C) It is highly soluble and diffuses easily into the surrounding water.
(D) It helps in the synthesis of trehalose.

2002

75. Match the environment/nematode state (List I) with the predominant nitrogenous waste strategy (List II):
List I: (Environment/State)
P. Aquatic
Q. Terrestrial (water-stressed)
R. Ascaris in host intestine
S. Starving nematode
List II: (Waste Strategy)
1. Increased urea production
2. Strict ammonotelism
3. Reduced total excretion
4. High ammonia mixed with urea
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

2022

76. Correct statement regarding urea excretion in nematodes:
(A) The enzymes of the ornithine-urea cycle are present in some species for urea synthesis.
(B) It is the sole nitrogenous waste product in all nematodes.
(C) It diffuses faster than ammonia through the cuticle.
(D) It is highly toxic compared to ammonia.

2022

77. Identify the INCORRECT statement about nitrogenous waste elimination:
(A) A significant amount of ammonia diffuses directly across the body wall.
(B) Nitrogenous wastes are completely converted to solid uric acid pellets.
(C) The intestine plays a major role in nitrogenous waste excretion.
(D) The excretory system assists in eliminating nitrogenous by-products.

2012

78. Identify the correct pair regarding nitrogen metabolism:
(A) Ammonotelic - Excreting primarily uric acid
(B) Ureotelic - Excreting primarily urea
(C) Uricotelic - Excreting primarily ammonia
(D) Aminotelic - Excreting primarily guanine

2019

79. If a nematode is placed in a confined, low-volume aqueous environment, the rapid accumulation of its own waste will primarily cause:
(A) Ammonia toxicity leading to neurological and physiological dysfunction
(B) Uric acid crystallization in the pseudocoelom
(C) Spontaneous moulting
(D) Accelerated lipid synthesis

2003

80. Match the excretion mechanism (List I) to the organ (List II):
List I: (Mechanism)
P. Direct diffusion of NH3
Q. Secretion of waste-laden fluid
R. Elimination of undigested nitrogenous matter
S. Intracellular protein degradation
List II: (Organ)
1. Intestine/Anus
2. Cuticle/Body wall
3. Lysosomes
4. Excretory pore
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

2002

81. The lack of a concentrated, solid waste excretion mechanism (like uric acid) limits most nematodes to:
(A) Exclusively anaerobic metabolism
(B) A strictly herbivorous diet
(C) Constant continuous feeding
(D) Environments with some degree of moisture to facilitate diffusion

2025

82. Which of the following is NOT a pathway for nitrogenous waste elimination in nematodes?
(A) Diffusion across the cuticle
(B) Expulsion via the excretory pore
(C) Exhalation via specialized spiracles
(D) Defecation via the anus

2009

83. All of the following enzymes might be involved in nematode nitrogen metabolism EXCEPT:
(A) Arginase
(B) Nitrogenase
(C) Urease
(D) Glutamate dehydrogenase

2024

84. Most appropriate reason why terrestrial nematodes still rely heavily on ammonia excretion:
(A) They lack the genetic capability to form urea.
(B) Ammonia is a required signaling molecule

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for host roots.
(C) Ammonia prevents cuticle degradation.
(D) The soil pore water provides a sufficient aqueous sink for diffusion

2010

85. Read the following statements regarding nematode aerobic respiration:
I. Cytochrome c oxidase is the terminal electron acceptor.
II. Energy generation primarily occurs via glycolysis alone.
III. The TCA cycle operates in the mitochondria.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II
(D) I

2001

86. Intermediary metabolism in fully aerobic nematodes mirrors that of higher metazoans primarily by utilizing:
(A) The reverse TCA cycle exclusively
(B) Methanogenesis
(C) The Embden-Meyerhof-Parnas pathway and TCA cycle
(D) Photorespiration

2013

87. Correct statement about anaerobic adaptations in parasitic nematodes (e.g., Ascaris):
(A) They utilize a modified electron transport chain with rhodoquinone.
(B) They possess functional chloroplasts.
(C) They completely lack mitochondria.
(D) They excrete oxygen as a waste product.

2018

88. Identify the INCORRECT statement regarding nematode respiration:
(A) Gas exchange occurs directly across the body wall.
(B) Specialized respiratory organs like gills are absent.
(C) Some species produce hemoglobin to scavenge low levels of oxygen.
(D) Nematodes utilize specialized hemolymph vessels for oxygen transport.

2013

89. Identify the correct pair of metabolic state and adaptation:
(A) Normoxia - Predominant fermentation end-products
(B) Hypoxia in intestine - Phosphoenolpyruvate (PEP) carboxykinase pathway activation
(C) Anoxybiosis - High oxygen consumption rate
(D) Normoxia - Absence of mitochondrial activity

2019

90. Read the following statements regarding nematode anaerobic metabolism:
I. Rhodoquinone replaces ubiquinone.
II. Fumarate acts as the terminal electron acceptor.
III. Succinate is a major excreted end-product.
IV. The process yields more ATP per glucose than aerobic respiration.
Which of the above statements are correct?
(A) I, II and III
(B) IV
(C) I and IV
(D) II and IV

2012

91. If an inhibitor of fumarate reductase is applied to Ascaris suum, the most likely immediate metabolic result is:
(A) Increased production of succinate
(B) Rapid switch to complete aerobic glycolysis
(C) Hyperactivation of the TCA cycle
(D) Cessation of anaerobic ATP production and parasite death

2016

92. The production of high-affinity hemoglobins by some nematodes in oxygen-depleted niches allows them to:
(A) Facilitate oxygen diffusion to tissues despite low external partial pressure
(B) Fix nitrogen from the environment
(C) Inactivate host proteases
(D) Transport carbon dioxide more efficiently

2006

93. Classification of the energy metabolism of adult Ascaris in the host gut:
(A) Obligate aerobic
(B) Facultative anaerobic relying on malate dismutation
(C) Obligate fermentative yielding ethanol
(D) Photoautotrophic

2015

94. Which of the following is NOT an end-product of anaerobic metabolism in nematodes?
(A) Succinate
(B) Uric acid
(C) Propionate
(D) Acetate

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(A) They are solely waste products of metabolism.
(B) They must be acquired from the host's diet.
(C) They are synthesized primarily in the cuticle.
(D) Dopamine and serotonin modulate complex behaviors like learning and mating.

2019

137. Identify the INCORRECT statement about neuromuscular transmission:
(A) Acetylcholinesterase (AChE) terminates the signal by degrading ACh.
(B) The muscle cells synthesize their own ACh to auto-stimulate.
(C) GABA binding leads to chloride influx and hyperpolarization.
(D) Neurotransmitters are released across synapses on muscle arms.

2010

138. Identify the correct pair regarding neuropharmacology:
(A) Levamisole - Inhibits GABA receptors
(B) Aldicarb - Blocks acetylcholine synthesis
(C) Ivermectin - Glutamate-gated chloride channel activator
(D) Piperazine - Acetylcholinesterase inhibitor

2008

139. Application of an acetylcholinesterase inhibitor to a nematode will result in:
(A) Flaccid paralysis due to lack of ACh
(B) Immediate increase in directed movement
(C) Rapid shedding of the cuticle
(D) Spastic paralysis due to continuous ACh stimulation

2006

140. Match the drug/toxin (List I) to its specific mechanism in nematodes (List II):
List I: (Drug/Toxin)
P. Ivermectin
Q. Levamisole
R. Aldicarb
S. Piperazine
List II: (Mechanism)
1. ACh agonist (spastic paralysis)
2. AChE inhibitor
3. GABA agonist (flaccid paralysis)
4. Glutamate-gated Cl- channel activator
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

NODIA

2024

141. The release of GABA onto the contralateral muscles during locomotion causes:
(A) Immediate and permanent muscle contraction
(B) Relaxation of the opposing muscles, enabling smooth undulatory movement
(C) Rapid withdrawal of the stylet
(D) Movement in the reverse direction

2025

142. Which of the following is NOT a known biogenic amine neurotransmitter in nematodes?
(A) Serotonin
(B) Melatonin
(C) Dopamine
(D) Histamine

2006

143. Nematode synaptic vesicles typically store all of the following EXCEPT:
(A) Trehalose
(B) Acetylcholine
(C) GABA
(D) FMRFamide-like peptides

2008

144. Most appropriate description of FMRFamide-like peptides (FLPs) in nematodes:
(A) They are the main structural proteins of the nerve ring.
(B) They are primarily used for egg hatching signals.
(C) They are neuropeptides modulating various behavioral outputs.
(D) They are enzymes involved in cellulose digestion.

2006

145. Read the following statements regarding nematode biomechanics:
I. Contraction is achieved against the turgor of the pseudocoelom.
II. Circular muscles provide the main propulsive force.
III. The cuticle acts as an antagonist to muscle contraction.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I

2004

146. The typical form of propulsion in nematodes through fluid or soil films is:

base of the stylet.
II. The subventral glands usually empty into the median bulb.
III. Plant-parasitic nematodes lack an intestine.
IV. CWDEs are acquired horizontally from bacteria.
V. CWDEs are exclusively found in animal-parasitic species.
Which of the above statements are INCORRECT?
(A) III and V
(B) I, II and IV
(C) I and III
(D) II, IV and V

2008

106. Classification of feeding strategies involving CWDEs:
(A) Bacterivory
(B) Carnivory
(C) Phytoparasitism
(D) Omnivory

2019

107. All of the following are involved in the phytoparasitic feeding process EXCEPT:
(A) Stylet thrusting
(B) Pharyngeal pumping
(C) Secretion of effectors
(D) Phagocytosis by epidermal cells

2001

108. Most appropriate evolutionary significance of endogenous CWDEs in nematodes:
(A) Represents horizontal gene transfer events that enabled plant parasitism.
(B) Allows them to digest their own exuviae.
(C) Facilitates rapid degradation of the host's nervous system.
(D) Provides structural support to the nematode intestine.

2011

109. Primary structural feature of the nematode intestinal cell luminal surface:
(A) Cilia
(B) Microvillar brush border
(C) Flagella
(D) Cuticular lining

2023

110. Read the following statements regarding the nematode intestine:
I. It is lined with a thick chitinous cuticle.
II. It is composed of a single layer of epithelial cells.
III. The apical surface contains microvilli.
IV. It absorbs nutrients via endocytosis and transporters.
V. It consists of a highly muscular wall.
Which of the above statements are INCORRECT?
(A) I and V
(B) II and III
(C) IV and V
(D) I and II

2004

111. Correct statement about nutrient absorption in the nematode intestine:
(A) The microvilli significantly increase the surface area for absorption.
(B) It relies entirely on passive diffusion without membrane transporters.
(C) Nutrients are absorbed directly into a closed capillary network.
(D) Absorption occurs primarily in the esophagus.

2011

112. Identify the INCORRECT statement regarding the intestinal cells:
(A) They are active in the synthesis of lipids and glycogen.
(B) They contain prominent nuclei, mitochondria, and endoplasmic reticulum.
(C) They are ectodermal in origin.
(D) They possess a basolateral membrane facing the pseudocoelom.

2022

113. Identify the correct pair regarding intestinal structure:
(A) Basal lamina - Faces the intestinal lumen
(B) Apical membrane - Faces the pseudocoelom
(C) Lumen - Site of intracellular digestion
(D) Terminal web - Anchors microvilli and maintains cellular integrity

2008

114. Damage to the microvillar brush border by a chemical toxin would primarily result in:
(A) Immediate somatic muscle paralysis
(B) Rupture of the pseudocoelom
(C) Severe starvation due to absorption failure
(D) Loss of sensory perception

2002

115. Select the correct sequence of nutrient transit during absorption:
(A) Lumen → Apical membrane → Cytoplasm → Basolateral membrane → Pseudocoelom
(B) Pseudocoelom → Basolateral membrane → Cytoplasm → Apical membrane → Lumen

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2007

95. Read the following statements regarding the PEP carboxykinase pathway in nematodes:
I. It diverts PEP away from pyruvate kinase.
II. It converts PEP to oxaloacetate.
III. It functions primarily in highly oxygenated environments.
IV. It ultimately leads to malate production.
Which of the above statements are correct?
(A) I, II and IV
(B) III
(C) II and III
(D) I and III

2011

96. Most appropriate description of intermediary metabolism flexibility in nematodes:
(A) Strict reliance on a single metabolic pathway throughout the life cycle.
(B) Permanent loss of mitochondrial function upon entering a host.
(C) Ability to switch between aerobic TCA cycle and anaerobic malate dismutation depending on environmental oxygen.
(D) Dependency on host enzymes for glycolysis.

2011

97. The primary origin of synthesized cell-wall-degrading enzymes (CWDEs) in plant-parasitic nematodes is the:
(A) Intestinal brush border
(B) Renette cell
(C) Amphidial sheath cells
(D) Subventral and dorsal esophageal glands

2012

98. Which enzyme is classically secreted by the esophageal glands of cyst nematodes to degrade plant cell walls?
(A) Chitinase
(B) Lipase
(C) Beta-1,4-endoglucanase (Cellulase)
(D) Hyaluronidase

2016

99. Correct statement regarding esophageal gland secretions:
(A) They are released solely through the anus.
(B) They are injected into host tissues via the stylet.
(C) They function exclusively to digest animal proteins.
(D) They are synthesized in the pseudocoelom.

2021

100. Read the following statements regarding nematode digestion:
I. Extracellular digestion initiates in the host tissue or pharynx.
II. Intracellular digestion is completed in the intestinal epithelium.
III. The stylet is hollow to allow secretion and ingestion.
IV. Pectinases are secreted to macerate host plant tissue.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2011

101. Identify the correct pair regarding digestive enzymes and targets:
(A) Cellulase - Plant cellulose microfibrils
(B) Pectate lyase - Animal glycoproteins
(C) Protease - Starch granules
(D) Amylase - Bacterial cell walls

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2009

102. If a plant is engineered to express a highly effective cellulase inhibitor, the targeted plant-parasitic nematode will likely:
(A) Switch to feeding on soil bacteria
(B) Accumulate excess sugars in the intestine
(C) Fail to penetrate and migrate through the plant roots
(D) Develop an alternative stylet structure

2001

103. The muscular pumping of the median bulb in the esophagus causes:
(A) Suction of liquid food into the digestive tract
(B) Rapid synthesis of cuticlins
(C) Premature release of eggs
(D) Contraction of somatic muscles

2006

104. Which of the following is NOT a function of nematode esophageal glands?
(A) Synthesis of effector proteins
(B) Production of cellulases
(C) Production of pectinases
(D) Secretion of osmoregulatory compatible solutes

2006

105. Read the following statements regarding the digestive physiology of nematodes:
I. The dorsal gland usually empties near the

(A) Dorsal nerve cord - Major processing center
(B) Ventral nerve cord - Contains motor neuron cell bodies
(C) Lateral nerve cords - Primary motor control of dorsal muscles
(D) Circumpharyngeal ring - Solely responsible for osmoregulation

2023

127. A lesion completely severing the ventral nerve cord posterior to the nerve ring would most likely result in:
(A) Paralysis of the body muscles posterior to the lesion
(B) Complete loss of amphid sensory function
(C) Inability to pump the pharynx
(D) Immediate death due to respiratory failure

2019

128. The strict deterministic lineage of nematode neurons ensures:
(A) High variability between individuals
(B) Rapid generation of new neurons throughout life
(C) A highly stereotyped and mapped neural connectome
(D) Ability to regenerate the entire brain after injury

2013

129. Classification of the nematode nervous system:
(A) Simple nerve net
(B) Dorsal tubular cord
(C) Segmented ganglia in every body somite
(D) Bilaterally symmetrical with a circumpharyngeal ring and longitudinal cords

2001

130. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Nematodes possess a well-developed myelin sheath around their nerve axons.
Reason (R): Myelin allows for saltatory conduction of action potentials in some metazoans.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

131. All of the following are main longitudinal nerve cords in nematodes EXCEPT:
(A) Dorsal
(B) Medial
(C) Ventral
(D) Lateral

2014

132. Most appropriate description of neural processing in nematodes:
(A) Simple reflex arcs with minimal central integration
(B) Decentralized processing in the lateral chords
(C) Entirely governed by the hypodermis
(D) Complex integration at the nerve ring regulating behavior

2014

133. The primary excitatory neurotransmitter at the nematode neuromuscular junction is:
(A) Acetylcholine (ACh)
(B) Gamma-aminobutyric acid (GABA)
(C) Dopamine
(D) Serotonin

2021

134. The primary inhibitory neurotransmitter causing muscle relaxation in nematodes is:
(A) Glutamate
(B) Acetylcholine
(C) Gamma-aminobutyric acid (GABA)
(D) Octopamine

2004

135. Match the neurotransmitter (List I) with its primary role (List II):
List I: (Neurotransmitter)
P. Acetylcholine
Q. GABA
R. Serotonin
S. Octopamine
List II: (Role)
1. Inhibitory at NMJ
2. Excitatory at NMJ
3. Modulates feeding/egg laying
4. Stress response/locomotion modulation
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-4, S-2

2001

136. Correct statement regarding biogenic amines in nematodes:

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(C) Lumen → Basolateral membrane → Cytoplasm → Apical membrane → Pseudocoelom
(D) Apical membrane → Lumen → Cytoplasm → Basolateral membrane → Pseudocoelom

2003

116. The presence of numerous lysosomes in the intestinal cells suggests that:
(A) They trigger immediate programmed cell death (apoptosis)
(B) They secrete hydrochloric acid for extracellular digestion
(C) They are the main site for synthesis of neurotransmitters
(D) Intracellular digestion of macromolecules occurs after endocytosis

2005

117. Classification of the nematode intestine anatomically:
(A) Midgut
(B) Foregut
(C) Hindgut
(D) Malpighian tubule

2007

118. The nematode intestinal epithelium does NOT function as a site for:
(A) Digestion of nutrients
(B) Storage of energy reserves
(C) Primary synthesis of acetylcholine for the nervous system
(D) Excretion of some metabolic wastes

2018

119. Which cellular structure is least abundant in active absorptive intestinal cells?
(A) Myofibrils
(B) Mitochondria
(C) Rough Endoplasmic Reticulum
(D) Golgi apparatus

2009

120. Select the correct sequence of structures a food particle passes through:
(A) Stylet → Median bulb → Intestine → Rectum → Anus
(B) Stylet → Intestine → Median bulb → Rectum → Anus
(C) Median bulb → Stylet → Intestine → Rectum → Anus
(D) Intestine → Stylet → Median bulb → Rectum → Anus

2011

121. The central processing organ of the nematode nervous system is the:
(A) Subventral ganglion
(B) Circumpharyngeal nerve ring
(C) Ventral nerve cord
(D) Dorsal nerve cord

2023

122. The ventral nerve cord in nematodes is functionally characterized by:
(A) Having only sensory neurons
(B) Completely lacking ganglia
(C) Containing both motor and sensory fibers
(D) Directly innervating the amphids

2013

123. Correct statement regarding the circumpharyngeal nerve ring:
(A) It is located in the posterior tail region.
(B) It consists of a single large axon.
(C) It is the primary site of reproductive control.
(D) It consists primarily of neuropil and associated ganglia.

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2006

124. Identify the INCORRECT statement about the nematode central nervous system:
(A) It processes sensory input and coordinates motor output.
(B) The dorsal nerve cord is primarily motor in function.
(C) Commisures connect the dorsal and ventral nerve cords.
(D) The nerve ring wraps around the intestine.

2010

125. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): The nervous system of nematodes is characterized by eutely.
Reason (R): The exact number and connectome of neurons remain constant within a species, such as the 302 neurons in adult hermaphrodite C. elegans.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

126. Identify the correct pair regarding nerve cords:

(A) Gliding using ciliary action
(B) Crawling via peristaltic waves
(C) Undulatory locomotion (sinusoidal waves)
(D) Jet propulsion using the excretory pore

2012

147. Correct statement regarding the generation of movement:
(A) All longitudinal muscles contract simultaneously.
(B) Waves of contraction pass anteroposteriorly along the dorsal and ventral longitudinal muscles alternately.
(C) Lateral muscles are the primary drivers of forward motion.
(D) The cuticle remains rigid and does not bend.

2018

148. Identify the INCORRECT statement about the hydrostatic skeleton's role in locomotion:
(A) It transmits force from one part of the body to another.
(B) It prevents the body from flattening under muscle contraction.
(C) It provides the restoring force for muscle expansion.
(D) It actively generates ATP for muscle fibers.

2001

149. Identify the correct pair regarding locomotion mechanics:
(A) Antagonist - Internal hydrostatic pressure and cuticular elasticity
(B) Agonist - Circular muscles
(C) Wave propagation - From tail to head for forward movement
(D) Steering - Achieved by changing internal pseudocoelomic direction

2025

150. Read the following statements regarding locomotion in different environments:
I. In low viscosity fluids, nematodes slip heavily and move inefficiently.
II. Soil particles provide necessary leverage (fulcra) for efficient movement.
III. Nematodes use flagella to swim in deep water.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2023

151. If a nematode is placed in a completely frictionless liquid with no particulate matter, it will:
(A) Thrash continuously without significant forward progression
(B) Move forward at maximum speed
(C) Stop moving and enter cryptobiosis
(D) Use peristalsis to move

2015

152. The lack of circular somatic muscles in nematodes dictates that:
(A) They cannot bend their bodies
(B) They rely entirely on peristaltic motion
(C) They have low internal hydrostatic pressure
(D) They cannot easily alter their body diameter.

2010

153. Classification of the physical system allowing nematode locomotion:
(A) Rigid Exoskeleton
(B) Hydrostatic skeleton system
(C) Rigid Endoskeleton
(D) Pneumatic system

2001

154. Efficient undulatory locomotion in soil does NOT depend on:
(A) Coordination of dorsal and ventral contractions
(B) Internal hydrostatic pressure
(C) Presence of rigid jointed appendages
(D) Surface tension of the water film

2014

155. Read the following statements regarding nematode muscle contraction cycles:
I. Depolarization opens calcium channels.
II. Actin and myosin slide past each other.
III. Force is transferred via the muscle belly directly to the cuticle.
IV. The fibrillar zone must contract transversely.
Which of the above statements are correct?
(A) III and IV
(B) I and II
(C) II and III
(D) I and IV

2010

156. Most appropriate reason why undulatory waves must alternate dorso-ventrally:
(A) Simultaneous contraction would shorten the body without locomotion.
(B) It prevents the cuticle from tearing.
(C) It allows for more recovery time for neurons.
(D) It limits the movement to once per minute.

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2010

157. The primary anterior chemosensory organs of a nematode are the:
(A) Phasmids
(B) Amphids
(C) Cephalic papillae
(D) Spicules

2013

158. Phasmids are sensory structures primarily located in the:
(A) Anterior head region
(B) Lateral tail region
(C) Esophageal region
(D) Vulval region

2002

159. Correct statement regarding the amphids:
(A) They consist of a pore, a duct, a pouch, and ciliated sensory neurons.
(B) They are primarily mechanosensory in function.
(C) They are only found in Secernentean nematodes.
(D) They are involved in the synthesis of the eggshell.

2010

160. Read the following statements regarding the amphidial neurons:
I. They are primarily located in the anterior region.
II. They are involved in sensing chemical gradients.
III. They are connected directly to the midgut.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I, II and III

2003

161. Identify the correct pair regarding sensory structures and function:
(A) Phasmids - Primary organs for vision
(B) Ocelli - Detect gravitational force
(C) Cephalic papillae - Dedicated to oxygen sensing
(D) Amphids - Primary olfactory/chemosensory organs

2003

162. If a laser ablation specifically destroys the amphidial sensilla of an infective juvenile root-knot nematode, the organism will likely:
(A) Undergo immediate moulting
(B) Burst due to high internal pressure
(C) Lose its ability to locate host plant roots
(D) Learn to swim backward efficiently

2023

163. The secretion of viscous fluid from the amphidial sheath cells serves to:
(A) Paralyze potential prey
(B) Protect ciliated dendrites and facilitate chemical transport
(C) Digest soil bacteria externally
(D) Lubricate the stylet for penetration

2003

164. Classification of amphidial sensory neurons based on their terminal structure:
(A) Unipolar
(B) Multipolar
(C) Myelinated
(D) Modified ciliated dendrites

2007

165. Read the following statements regarding nematode sensilla:
I. They typically contain a socket cell and a sheath cell.
II. The socket cell is responsible for secreting the mucus.
III. The sensory neuron extends a dendrite into the sensillum.
Which of the above statements are correct?
(A) I and III
(B) II and III
(C) I and II
(D) I, II and III

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2007

166. Which of the following is NOT typically a part of a nematode sensillum?
(A) Socket cell
(B) Sheath cell
(C) Malpighian cell
(D) Sensory dendrite

2012

167. All of the following are primary functions of nematode sensory physiology EXCEPT:
(A) Synthesizing digestive enzymes for the intestine
(B) Locating potential mates
(C) Avoiding harmful chemical substances
(D) Detecting suitable hosts

2012

168. Most appropriate distinction between amphids and phasmids:

(A) Amphids are mechanosensory, while phasmids are chemosensory.
(B) Phasmids are used for sex determination, while amphids are not.
(C) Phasmids secrete silk, while amphids secrete venom.
(D) Amphids are anterior and phasmids are posterior.

2024

169. Nematodes detect concentration gradients of host exudates through:
(A) Visual perception of the roots
(B) Spatial and temporal sampling using their amphidial receptors
(C) Echolocation against soil particles
(D) Magnetic field detection

2010

170. Read the following statements regarding host-finding navigation:
I. Nematodes move toward higher concentrations of attractants.
II. Turning frequency increases as they move away from the source.
III. They use ocelli to find root tips.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I, II and III

2004

171. Correct statement about root exudate perception:
(A) Any organic acid will attract all nematode species.
(B) Roots exclusively repel nematodes.
(C) Exudates are detected by somatic muscles.
(D) Specific carbon compounds and metabolites act as attractants.

2011

172. Identify the INCORRECT statement regarding chemotaxis:
(A) Repellents trigger an immediate halt to all movement forever.
(B) Positive chemotaxis is movement toward a chemical source.
(C) A "pirouette" is a sudden reorientation turn during navigation.
(D) Chemoreception is essential for the survival of parasitic species.

2024

173. Identify the correct pair regarding chemoreception signaling:
(A) cAMP - Primary inhibitory molecule
(B) GPCR - Cell surface receptor for chemical cues
(C) Calcium - Solely used for structural support
(D) Kinase - Always located in the cuticle

2009

174. A mutation disabling the TAX-2/TAX-4 cyclic nucleotide-gated channels in a nematode's amphid would result in:
(A) Hypersensitivity to light
(B) Failure to transduce chemosensory signals, leading to chemotaxis defects
(C) Overproduction of amphidial mucus
(D) Enhanced ability to find hosts

2021

175. Read the following statements regarding the sequence of chemosensory transduction:
I. Binding of ligand to a receptor.
II. Opening of ion channels.
III. Change in membrane potential.
IV. Transmission of the signal to the nerve ring.
Which of the above statements describe the correct sequence?
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) III, II, I, IV

2007

176. The pirouette model of nematode navigation suggests that as attractant concentration decreases, the probability of turning:
(A) Decreases
(B) Remains unchanged
(C) Increases, allowing the nematode to reorient back up the gradient
(D) Reverses the direction of muscle wave propagation

2011

177. Classification of the receptors primarily responsible for nematode olfaction:
(A) Tyrosine kinases
(B) Ligand-gated chloride channels
(C) Piezo receptors
(D) G-protein coupled receptors (GPCRs)

2019

178. Which factor is LEAST likely to be a component of plant root exudates attracting phytoparasitic nematodes?
(A) CO2
(B) Amino acids
(C) Complex structural lignins

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(D) Sugars

2001

179. Chemosensory pathways in nematodes involve all of the following EXCEPT:
(A) Olfactory GPCRs
(B) Rhodopsin-mediated phototransduction
(C) G-proteins
(D) Calcium signaling

2004

180. Read the following statements regarding the interaction with host exudates:
I. Exudates are detected by sensory cilia.
II. Signal transduction occurs in the sheath cell.
III. Motor response is coordinated by the ventral nerve cord.
Which of the above statements are correct?
(A) I and III
(B) II and III
(C) I and II
(D) I, II and III

2021

181. Deterministic cell lineage in nematodes refers to:
(A) A strictly predictable pattern of cell divisions in embryos
(B) Random distribution of cells during development
(C) The ability of any cell to become any tissue at any time
(D) Uncontrolled proliferation of somatic cells

2016

182. The principle of eutely in nematodes means that:
(A) Nematodes grow by adding more somatic cells.
(B) Only hermaphrodites have a fixed cell number.
(C) Adults have a constant, species-specific number of somatic cells.
(D) The circulatory system has a fixed volume.

2017

183. The first cleavage in nematode embryogenesis:
(A) It produces a somatic founder cell and a germline precursor.
(B) It results in two equal, identical cells.
(C) It always produces four daughter cells simultaneously.
(D) It occurs only after the egg hatches.

2003

184. Identify the INCORRECT statement about eutely (cell constancy):
(A) Growth in adults is primarily through cell enlargement (hypertrophy).
(B) Eutely applies to somatic cells but not necessarily to the germline.
(C) C. elegans hermaphrodites have exactly 959 somatic nuclei.
(D) Eutely prevents any form of post-embryonic growth.

2002

185. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Nematodes have a high capacity for tissue regeneration.
Reason (R): Their development is governed by a rigid, deterministic cell lineage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

186. Identify the correct pair regarding embryonic founder cells:
(A) P4 cell - Produces the muscles
(B) E cell - Produces the nervous system
(C) AB cell - Primarily gives rise to hypodermis and nervous system
(D) MS cell - Produces the germline

2006

187. If a laser beam ablates the P4 cell at the 16-cell stage in a nematode embryo, the resulting adult will most likely:
(A) Lack an intestine
(B) Be completely paralyzed
(C) Die immediately
(D) Be unable to produce gametes.

2004

188. The rigid deterministic cleavage pattern in nematodes ensures that:
(A) Mutations in early founder cells have massive, often lethal, downstream effects
(B) Lost tissues can be easily regenerated
(C) Every adult of a species has a highly variable size
(D) Development takes several years to complete

2021

189. Classification of nematode embryonic development:
(A) Indeterminate

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(B) Determinate, modified spiral (or rotational) cleavage
(C) Superficial
(D) Discoidal

2017

190. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Somatic cell division ceases after the nematode reaches adulthood.
Reason (R): Adult nematodes increase their body size primarily by increasing the number of cells in the midgut.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

191. Which tissue is typically EXEMPT from strict eutely in the adult nematode?
(A) Germ cells (gametes)
(B) Nervous tissue
(C) Somatic muscle tissue
(D) Intestinal epithelium

2013

192. Most appropriate definition of a founder cell in nematode embryogenesis:
(A) A cell that dies immediately after division.
(B) The first cell that hatches from the egg.
(C) A precursor cell that gives rise to specific lineages.
(D) A cell that only secretes the cuticle.

2022

193. Nematode spermatogenesis is unique because the mature spermatozoa:
(A) Possess multiple flagella
(B) Are identical to human sperm
(C) Move using a long tail
(D) Are amoeboid and lack flagella.

2008

194. In the XX/XO sex determination system of many nematodes, the males are:
(A) XX (homogametic)
(B) XY (heterogametic)
(C) XO (heterogametic with one sex chromosome)
(D) ZW (heterogametic)

2006

195. Read the following statements regarding nematode reproduction:
I. Males often possess spicules for copulation.
II. Sperm move by crawling in the female reproductive tract.
III. Fertilization is always external in the soil.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2011

196. Correct statement regarding oogenesis in nematodes:
(A) Oocytes develop from the proximal to the distal end of the ovary.
(B) Oocytes mature at the distal tip of the gonad.
(C) Nematode eggs contain no yolk.
(D) Maturation and meiotic progression are often triggered by signals from sperm.

2023

197. Identify the INCORRECT statement about amoeboid sperm mechanics:
(A) They swim through the pseudocoelom to reach the ovary.
(B) They utilize Major Sperm Protein (MSP) for motility.
(C) They lack actin-based lamellipodia.
(D) They crawl up the uterus to reach the spermatheca.

NODIA

2015

198. Identify the correct pair regarding reproduction:
(A) Syngamy - Fusion of two identical somatic cells
(B) Hermaphroditism - Possession of only male reproductive organs
(C) Parthenogenesis - Development of an embryo from an unfertilized egg
(D) Spermatogenesis - Production of flagellated swimming sperm

2013

199. If a chemical specifically inhibits the polymerization of Major Sperm Protein (MSP), the reproductive consequence will be:
(A) Sperm will be unable to crawl to the spermatheca, causing sterility.
(B) Sperm will swim faster toward the egg.
(C) Oocytes will divide more rapidly.
(D) Males will switch to being hermaphrodites.

2005

200. Read the following statements regarding the nematode gonad:
I. It is often a tubular structure.
II. It contains a distal tip cell (DTC) that regulates cell division.
III. The germline is the only tissue that continues to divide in adults.
Which of the above statements are correct?
(A) I, II and III
(B) I and II
(C) II and III
(D) I and III

2002

201. The presence of a distal tip cell in the nematode gonad ensures:
(A) Immediate cell differentiation
(B) Maintenance of a mitotic germline stem cell niche via Notch signaling
(C) Ejection of mature sperm into the soil
(D) Rapid synthesis of lipid reserves

2023

202. Classification of the C. elegans standard sex forms:
(A) Males and Females
(B) Females and males
(C) Self-fertilizing hermaphrodites and Males
(D) Strictly parthenogenetic forms

2005

203. Which feature is NOT associated with nematode spermatozoon?
(A) Pseudopodia
(B) MSP (Major Sperm Protein)
(C) Membranous organelles
(D) Axoneme (9+2 microtubule arrangement)

2025

204. The nematode reproductive tract typically includes all of the following EXCEPT:
(A) Fallopian tube
(B) Ovary
(C) Spermatheca
(D) Uterus

2010

205. The physiology of nematode moulting is primarily regulated by:
(A) Soil temperature alone
(B) Endocrine signaling pathways, including nuclear hormone receptors
(C) Eggshell thickness
(D) Photoperiodic changes in the deep sea

2022

206. How many moults does a typical nematode undergo during its life cycle?
(A) Two
(B) Three
(C) Four
(D) Five

2013

207. Correct statement regarding the degradation of the old cuticle:
(A) It is dissolved by enzymes secreted by the hypodermis.
(B) It is mechanically broken by the nematode's teeth.
(C) It is absorbed by the host plant.
(D) It remains intact and is never shed.

2011

208. Identify the INCORRECT statement about the synthesis of the new exoskeleton:
(A) It occurs during a phase called apolysis.
(B) It involves the secretion of new structural proteins.
(C) New collagens are synthesized and secreted by the hypodermis.
(D) It is governed by a random set of genes every time.

2003

209. Identify the correct pair regarding moulting phases:
(A) Apolysis - Hardening of the new cuticle
(B) Ecdysis - Separation of the old cuticle from the hypodermis
(C) Eutel - The process of shedding the old cuticle
(D) Lethargus - A period of reduced behavioral activity preceding ecdysis

2001

210. If an inhibitor of zinc metalloproteases is applied during lethargus, the most likely result is:
(A) Premature hatching of the eggs
(B) Increased feeding activity
(C) Failure of the old cuticle to degrade, resulting in incomplete ecdysis (moulting block)
(D) Sudden conversion of the female to a male

2019

211. The structural modification of the new cuticle immediately after ecdysis involves extensive tyrosine cross-linking, which causes:
(A) The cuticle to become more permeable to water
(B) Hardening and stabilization of the new

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exoskeleton
(C) The immediate initiation of the next moult
(D) Complete dissolution of the underlying hypodermis

2011

212. Classification of the moulting process biologically:
(A) Metamorphosis
(B) Regeneration
(C) Parthenogenesis
(D) Ecdysis

2007

213. Which event does NOT typically occur during nematode moulting?
(A) Complete dedifferentiation of the nervous system
(B) Cessation of feeding
(C) Shedding of the lining of the esophagus and rectum
(D) Synthesis of a new epicuticle

2008

214. Hormonal control of moulting in nematodes involves molecules similar to those found in arthropods, such as:
(A) Thyroxine
(B) Insulin
(C) Ecdysone-like sterols
(D) Estrogen

2022

215. Most appropriate significance of the moulting process:
(A) Permits step-wise growth despite a restrictive exoskeleton.
(B) Allows the nematode to change its genetic code.
(C) Is the primary way the nematode achieves nitrogen excretion.
(D) Triggers a permanent switch to anaerobic metabolism.

2025

216. Read the following statements regarding the regulation of moulting:
I. Environmental cues can trigger the release of moulting hormones.
II. Nuclear hormone receptors play a key role in the transcriptional response.
III. The process is completely independent of the hypodermis.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I, II and III

NODIA

2021

217. The primary stimulus for egg hatching in many specialized plant-parasitic nematodes (like Globodera) is:
(A) Low oxygen levels
(B) Root exudates containing specific hatching factors
(C) Complete darkness
(D) Sudden desiccation

2014

218. The nematode eggshell typically consists of three main layers:
(A) Cortical, median, and basal
(B) Epicuticle, cortical, and fibrous
(C) Vitelline, chitinous, and lipid
(D) Proteinaceous, collagenous, and glycoprotein

2014

219. Correct statement regarding the alteration of eggshell permeability during hatching:
(A) The shell is crushed by soil particles.
(B) Hatching occurs due to built up pressure from gases.
(C) The chitin layer dissolves entirely in soil water.
(D) Hatching factors cause structural changes in the lipid layer.

2008

220. Identify the INCORRECT statement about juvenile emergence:
(A) Emergence is entirely a passive process driven by osmotic swelling.
(B) It involves vigorous muscular activity of the juvenile.
(C) The juvenile uses its stylet to create an opening in the shell.
(D) Proteases may be involved in softening the shell.

2007

221. Identify the correct pair regarding egg hatching:
(A) Hatching factor - A mineral found in soil
(B) Trehalose efflux - Decreases internal osmotic pressure, signaling hatching readiness
(C) Chitinase - Enzyme that synthesizes the lipid layer
(D) Stylet - Organ used to absorb soil water into the egg

2008

222. If a field infested with potato cyst nematodes is planted with a non-host plant that does not

secrete the required hatching factor, the eggs will:
(A) Hatch immediately and die
(B) Remain dormant in the soil for years
(C) Develop into adults inside the shell
(D) Mutate into a new species

2004

223. The loss of trehalose from the egg fluid just prior to hatching leads to:
(A) Hydration and activation of the juvenile's metabolism and movement
(B) Immediate desiccation of the juvenile
(C) Hardening of the chitinous layer
(D) Cessation of all juvenile movement

2003

224. Classification of the hatching dependency in cyst nematodes:
(A) Facultative
(B) Spontaneous
(C) Obligate host-stimulated hatching
(D) Photoperiodic

2011

225. Which of the following is NOT involved in the physiology of nematode egg hatching?
(A) Changes in the permeability of the lipid layer
(B) Secretion of enzymes by the juvenile
(C) Repeated thrusting of the stylet
(D) Massive synthesis of glycogen in the eggshell

2014

226. Factors that can influence the spontaneous hatching of non-specialized nematodes include all EXCEPT:
(A) Soil moisture
(B) Ambient temperature
(C) Absence of any gravitational field
(D) Soil aeration

2016

227. Most appropriate description of the eggshell lipid layer's role:
(A) It provides the main structural rigidity to the egg.
(B) It acts as an impermeable barrier protecting the juvenile.
(C) It is the primary food source for the hatching juvenile.
(D) It actively absorbs water from the soil to trigger hatching.

2008

228. Identify the INCORRECT statement regarding the mechanics of emergence:
(A) Enzymes from the esophageal gland assist in shell degradation.
(B) The juvenile must overcome the physical resistance of the eggshell.
(C) Rhythmic contractions of the body muscles are required.
(D) Emergence is always synchronized to happen at night.

2025

229. Cryptobiosis in nematodes refers to:
(A) A temporary, reversible state of suspended animation in response to adverse environmental conditions
(B) A hyperactive state used for finding hosts
(C) The process of hiding in soil crevices
(D) A permanent state of reproduction

2001

230. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Anhydrobiotic nematodes can survive for decades in a dry state.
Reason (R): Their metabolic rate is reduced to an undetectable level, and they accumulate protective sugars like trehalose.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

231. Match the type of cryptobiosis (List I) with the environmental stress (List II):
List I: (Type of Cryptobiosis)
P. Anhydrobiosis
Q. Cryobiosis
R. Anoxybiosis
S. Osmobiosis
List II: (Stress)
1. Freezing
2. Desiccation
3. High salinity
4. Lack of oxygen
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

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2001

232. Correct statement regarding morphological changes during anhydrobiosis:
(A) The nematode expands its body to absorb more moisture.
(B) The cuticle is completely shed to expose the hypodermis.
(C) All internal fluids are expelled as solid crystals.
(D) The nematode coils tightly to reduce surface area.

2005

233. Identify the INCORRECT statement about the biochemistry of survival:
(A) Trehalose prevents the crystallization of intracellular proteins.
(B) Metabolism shifts entirely to rapid aerobic glycolysis.
(C) Late Embryogenesis Abundant (LEA) proteins protect against dehydration.
(D) A significant drop in metabolic rate is essential for survival.

2014

234. Identify the correct pair regarding stress responses:
(A) Glycerol - Used only during high oxygen levels
(B) Coiling - Increases the rate of water loss
(C) LEA proteins - Act as molecular chaperones in dry states
(D) Heat shock proteins - Decrease the nematode's tolerance to heat

2009

235. Read the following statements regarding the sequence of entering anhydrobiosis:
I. Gradual loss of body water.
II. Induction of trehalose synthesis.
III. Formation of a coil (tun).
IV. Cessation of detectable metabolism.
Which of the above statements describe the correct sequence?
(A) II, I, III, IV
(B) I, II, III, IV
(C) III, I, II, IV
(D) IV, III, II, I

2022

236. The vitrification (glass-forming) ability of trehalose during severe dehydration directly prevents:
(A) Mechanical disruption of cellular structures by ice crystals or massive shrinkage
(B) Any future rehydration of the organism
(C) The entry of gases into the pseudocoelom
(D) The initiation of parasitism

2010

237. Classification of cryobiosis adaptation:
(A) Survival of extreme Heat
(B) Survival of freezing through ice nucleation management and antifreeze synthesis
(C) Survival of high salinity environments
(D) Survival of exposure to toxic chemicals

2015

238. Which of the following is NOT required for successful entry into anhydrobiosis?
(A) Slow and controlled rate of drying
(B) Immediate, rapid drying in seconds
(C) Accumulation of non-reducing disaccharides
(D) Morphological coiling

2016

239. If a nematode genetically incapable of synthesizing trehalose is subjected to slow desiccation, it will most likely:
(A) Suffer irreversible membrane damage and die
(B) Synthesize glucose instead and survive
(C) Undergo moulting normally
(D) Enter the dauer stage immediately

2003

240. Read the following statements regarding the sequence of rehydration from anhydrobiosis:
I. Absorption of water from the environment.
II. Resumption of metabolic activity.
III. Degradation of protective trehalose.
IV. Initiation of movement.
Which of the above statements describe the correct sequence?
(A) I, II, III, IV
(B) II, I, III, IV
(C) III, II, I, IV
(D) I, III, II, IV

NODIA

2018

241. Environmental triggers for dauer larva formation primarily include:
(A) Abundance of food
(B) Total darkness
(C) Freezing temperatures
(D) Starvation, high population density (dauer pheromone), and high temperature

2005

242. The dauer larva is typically a developmentally arrested form of which larval stage?
(A) L1

(B) Marine nematode
(C) Free-living, soil-dwelling bacterivore
(D) Intestinal commensal

2016

263. Which of the following is NOT a characteristic of C. elegans that makes it an ideal model organism?
(A) Three-year lifespan
(B) Hermaphroditic reproduction
(C) Small body size
(D) Small, sequenced genome

2002

264. C. elegans research has fundamentally illuminated all the following human biological processes EXCEPT:
(A) Aging and longevity
(B) Sleep and circadian rhythms
(C) Programmed cell death
(D) Adaptive immunity with antibodies

2001

265. Nematode-secreted effector proteins (parasitism genes) primarily originate in the:
(A) Amphids
(B) Subventral and dorsal esophageal glands
(C) Intestinal brush border
(D) Excretory pore

2018

266. How are effector proteins typically delivered into host plant cells?
(A) Simple diffusion across the cuticle
(B) Release during the moulting process
(C) Injected directly through the hollow oral stylet
(D) Carried by symbiotic bacteria

2010

267. Correct statement regarding the function of nematode effectors:
(A) They only digest the plant cell wall.
(B) they are toxic only to the nematode itself.
(C) They provide structural support to the stylet.
(D) They manipulate host expression and signaling to establish feeding sites.

2010

268. Identify the INCORRECT statement about the origin of nematode parasitism genes:
(A) Many are thought to have been acquired via horizontal gene transfer (HGT) from soil bacteria and fungi.
(B) They are all present in non-parasitic nematodes.
(C) Their expression is tightly regulated during the infection process.
(D) Specific esophageal glands express specific effectors at different times.

2021

269. Identify the correct pair regarding effector glands:
(A) Dorsal gland - Primarily used for excretion
(B) Subventral glands - Mostly active during early penetration and migration
(C) Renette cell - Primary source of pectinases
(D) Amphidial sheath - Main site of cellulase synthesis

2007

270. If a plant is engineered to express small RNAs that silence a critical dorsal gland effector gene in the nematode, the nematode will likely:
(A) Migrate to the root cortex and die immediately
(B) Penetrate the root but fail to establish or maintain a specialized feeding site
(C) Change into a male and leave the root
(D) Become a parasite of soil fungi instead

2006

271. The acquisition of cellulases and pectate lyases via horizontal gene transfer allowed ancestral nematodes to:
(A) Overcome cell wall barriers and become plant parasites.
(B) Digest host insect exoskeletons.
(C) Produce trehalose more efficiently.
(D) Survive in deep-sea desiccation.

2003

272. Classification of effector delivery location during feeding site initiation:
(A) Strictly vacuolar delivery
(B) Delivery into the xylem only
(C) Apoplastic (outside the host membrane) and symplastic/cytoplasmic (inside the host cell)
(D) Delivery into the soil surrounding the root

2006

273. Which of the following is NOT a known function of plant-parasitic nematode effectors?
(A) Mimicking plant hormones like auxin
(B) Suppressing the host hypersensitive response (HR)
(C) Modifying the host cell cytoskeleton
(D) Synthesizing host chloroplasts de novo

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bust cycles and disperse.
(B) Increases the rate of genetic mutations.
(C) Ensures the nematode is eaten by hosts.
(D) Promotes the development of a large body size.

2010

253. C. elegans is recognized as a premier biological model organism primarily because of its:
(A) Extreme morphological complexity
(B) Genetic amenability, transparency, and mapped connectome.
(C) Ability to parasitize humans and livestock.
(D) Large brain with billions of neurons.

2023

254. Sydney Brenner established C. elegans as a model primarily to study:
(A) Soil pathology
(B) Neurobiology and developmental genetics
(C) Carbon sequestration
(D) Marine biology

2014

255. Match the C. elegans feature (List I) with its description (List II):
List I: (Feature)
P. Eutely
Q. Transparency
R. Hermaphroditism
S. Connectome
List II: (Description)
1. Allows for self-fertilization
2. Constant cell number
3. Map of all neural synapses
4. Facilitates live imaging
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

2008

256. Correct statement regarding apoptosis discovery in C. elegans:
(A) Cells die randomly during development.
(B) Programmed cell death is absent in nematodes.
(C) Exactly 131 specific cells undergo programmed death.
(D) Apoptosis only occurs in the adult stage.

2024

257. Identify the INCORRECT statement about the C. elegans neural connectome:
(A) It consists of exactly 302 neurons.
(B) It maps every synapse in the nervous system.
(C) It is used to study the neural basis of behavior.
(D) The connectome varies significantly between individual wild-type hermaphrodites.

2011

258. Identify the correct pair regarding C. elegans genetics:
(A) unc genes - Affect cuticle synthesis
(B) daf genes - Affect digestion only
(C) ced genes - Cell death (apoptosis) abnormal
(D) rol genes - Affect the reproductive rate

2001

259. If a researcher knocks out the ced-3 gene (homologous to mammalian caspases) in C. elegans, the resulting phenotype will likely be:
(A) Immediate death of the embryo
(B) Survival of extra cells that normally would have undergone apoptosis
(C) Loss of the entire nervous system
(D) Formation of a constitutive dauer

2017

260. Match the Nobel Prize winning topic (List I) with the researcher (List II):
List I: (Research Topic)
P. Programmed Cell Death
Q. RNA Interference
R. Green Fluorescent Protein
S. Genetic Regulation of Development
List II: (Researcher)
1. Brenner, Horvitz, Sulston
2. Fire and Mello
3. Chalfie
4. Sulston
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2007

261. The ability to easily perform RNA interference (RNAi) by simply feeding C. elegans engineered bacteria allows for:
(A) High-throughput, whole-genome reverse genetics screens
(B) Rapid production of new random mutations
(C) Thickening of the nematode cuticle
(D) Permanent changes to the somatic chromosomes

2021

262. Classification of C. elegans ecologically and biologically:
(A) Obligate animal parasite

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(B) L2
(C) L3
(D) L4

2013

243. Correct statement regarding the morphological shifts in a dauer larva:
(A) The oral opening becomes wider to allow more feeding.
(B) It forms a specialized, highly impermeable cuticle and a sealed oral opening.
(C) Body becomes shorter and wider.
(D) The reproductive organs develop prematurely.

2022

244. Identify the INCORRECT statement about the dauer stage physiology:
(A) It does not feed.
(B) It relies on stored lipid reserves.
(C) it is highly resistant to environmental toxins.
(D) It exhibits a massively increased metabolic rate to find new food.

2003

245. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): The dauer stage is an alternative to the normal L3 stage.
Reason (R): It allows the nematode to survive adverse conditions and disperse to new habitats.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

246. Identify the correct pair regarding dauer regulation pathways:
(A) Insulin signaling - Always promotes dauer formation
(B) Dauer pheromone - Signals that food is abundant
(C) DAF-16 (FOXO transcription factor) - Promotes dauer formation when active/ nuclear
(D) TGF-beta signaling - Only active in adult nematodes

2006

247. A loss-of-function mutation in the daf-2 gene (insulin-like receptor) will result in:
(A) Constitutive dauer formation even in the presence of abundant food (dauer-constitutive)
(B) Inability to ever form a dauer larva (dauer-defective)
(C) Immediate hatching of eggs in the soil
(D) Formation of a Giant cell in host roots

2014

248. The sealing of the buccal cavity and formation of a thickened cuticle in the dauer stage directly confers:
(A) The ability to digest complex proteins
(B) Rapid somatic growth
(C) The ability to mate during the dauer stage
(D) Resistance to harsh external chemicals and desiccation

NODIA

2017

249. Classification of the dauer stage in the nematode life cycle:
(A) Obligate developmental stage
(B) Facultative, alternative developmental diapause stage
(C) Final adult stage
(D) Embryonic resting stage

2023

250. Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R). In the light of the above statements, choose the correct answer from the options given below:
Assertion (A): Dauer larvae have an increased lifespan compared to normal L3 larvae.
Reason (R): They enter a state of metabolic depression and do not age during the dauer period.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

251. Dauer larva characteristics include all of the following EXCEPT:
(A) Radial shrinkage of the body
(B) Suspension of aging
(C) Shift to specialized lipid metabolism
(D) Active feeding and digestion

2017

252. Most appropriate evolutionary benefit of the dauer stage:
(A) Allows populations to survive boom-and-

2018

274. The secretion system for effectors involves all EXCEPT:
(A) Endoplasmic Reticulum and Golgi apparatus
(B) Regulated secretion of granules
(C) Phasmids
(D) Oral stylet

2009

275. Most appropriate significance of the "dorsal gland" in sedentary endoparasites:
(A) It produces all the digestive enzymes for the midgut.
(B) It becomes enlarged to continuously secrete feeding site effectors.
(C) It is the primary respiratory organ.
(D) It governs the moulting cycle.

2005

276. Correct statement regarding the specificity of effectors:
(A) All nematode species possess identical effectors.
(B) Effectors are completely absent in cyst nematodes.
(C) Effectors are only delivered to host mitochondria.
(D) Effector repertoires are highly diverse and determine host range and parasitism strategy.

2013

277. Cytological mechanism of Giant Cell formation by Root-knot nematodes (Meloidogyne spp.):
(A) Synchronous karyokinesis (nuclear division) without cytokinesis (cell division)
(B) Protoplast fusion of many cells
(C) Rapid proliferation of small somatic cells
(D) Programmed cell death of neighboring cells

2024

278. Giant cells induced by root-knot nematodes become:
(A) Uninucleate and dormant
(B) Devoid of any organelles
(C) Multinucleate and highly metabolically active
(D) Dead cells used as structural support

2006

279. Correct statement regarding endoreduplication in Giant Cells:
(A) It involves DNA replication without nuclear division.
(B) It results in a reduction of total DNA content.
(C) It leads to immediate cell death.
(D) It decreases the metabolic capacity of the cell.

2002

280. Identify the INCORRECT statement about Giant Cells:
(A) Typically, 5 to 7 cells are induced per nematode.
(B) They are always located within the vascular cylinder.
(C) They function as specialized metabolic sinks.
(D) They are formed by cell wall dissolution between adjacent cells.

2011

281. Identify the correct pair regarding Giant Cell cytology:
(A) Karyokinesis - The process of cell wall dissolution
(B) Cytokinesis - Completely absent or bypassed during formation
(C) Cell wall ingrowths - Located only on the nematode cuticle
(D) Central Vacuole - Becomes larger and larger until the cell bursts

2015

282. Inhibition of the host plant's cell cycle machinery (e.g., cyclin-dependent kinases) specifically at the feeding site would result in:
(A) Increased Giant Cell size
(B) Rapid spread of the nematode to other roots
(C) Failure of the cells to undergo karyokinesis and endoreduplication, starving the nematode
(D) Premature reproduction of the nematode

2014

283. The development of extensive cell wall ingrowths in mature Giant Cells leads to:
(A) Starvation of the nematode
(B) Lysis of the host cell
(C) Prevention of nutrient uptake
(D) Increased plasma membrane surface area for active transport

2024

284. Classification of Giant Cells functionally:
(A) Specialized metabolic sinks supplying continuous nutrition
(B) Passive transport vessels
(C) Structural barriers against other parasites
(D) Host defense organs

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2025

285. Which cytological feature is NOT characteristic of an active Giant Cell?
(A) Dense, granular cytoplasm
(B) Large central vacuole displacing all cytoplasm
(C) Multiple enlarged nuclei
(D) High rate of organelle proliferation

2005

286. The induction of Giant Cells involves the manipulation of host:
(A) Auxin levels
(B) Cytokinin signaling
(C) Cell cycle regulation
(D) Photosynthetic pathways

2021

287. Most appropriate description of the nematode's dependence on Giant Cells:
(A) Obligate; the sedentary female absolutely depends on the continuous viability of these cells.
(B) Facultative; the nematode can leave the feeding site if needed.
(C) Temporary; the cells are only needed during the first moult.
(D) Incidental; the cells are a side-effect of infection.

2002

288. Read the following statements regarding the sequence of Giant Cell development:
I. Induction of nuclear division.
II. Failure of cytokinesis.
III. Endoreduplication.
IV. Formation of cell wall ingrowths.
Which of the above statements describe the correct sequence?
(A) I, II, III, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) IV, III, II, I

2008

289. Cytological mechanism of Syncytia formation by Cyst nematodes (Heterodera / Globodera spp.):
(A) Synchronous nuclear division
(B) Viral transformation of roots
(C) Hypertrophy of a single cell
(D) Dissolution of cell walls and protoplast fusion of adjacent cells

2017

290. A syncytium expands primarily by:
(A) Rapid mitotic divisions of the initial cell
(B) Inflating with water from the xylem
(C) Incorporating neighboring cells through partial wall degradation
(D) Absorbing the contents of the nematode's intestine

2005

291. Correct statement regarding cell wall dissolution in syncytia:
(A) Walls are vaporized by the stylet.
(B) Targeted enzymatic degradation occurs at specific pit fields.
(C) Walls are broken by the physical pressure of the nematode's head.
(D) Dissolution only occurs in dead cells.

2014

292. Identify the INCORRECT statement about Syncytia:
(A) They are multinucleate structures.
(B) They possess extensive wall ingrowths.
(C) They function as specialized sinks.
(D) The nuclei within a syncytium undergo synchronous mitosis without cytokinesis.

NODIA

2010

293. Identify the correct pair regarding the differences between Giant Cells and Syncytia:
(A) Syncytia - Formed by protoplast fusion
(B) Giant Cells - Formed by cell fusion
(C) Syncytia - Located only in the root cap
(D) Giant Cells - Completely lack a central vacuole

2013

294. If a plant mutant lacks the enzymes necessary for localized cell wall degradation (e.g., specific endoglucanases), infection by cyst nematodes will most likely result in:
(A) Unusually large syncytia
(B) Formation of giant cells instead
(C) Arrested syncytium expansion and subsequent nematode death/starvation
(D) Immediate conversion of the juvenile to a cyst

2006

295. The progressive incorporation of hundreds of host cells into a single syncytium allows the cyst nematode to:
(A) Access a massive, continuously expanding nutrient pool.
(B) Evade host detection by hiding inside the cells.
(C) Migrate to the leaves of the plant.
(D) Alter the host's reproductive hormones.

2015

296. Classification of the mature syncytium:
(A) Benign tumor
(B) Apoplastic reservoir
(C) Necrotic tissue
(D) Multinucleate fused cellular continuum (symplast)

2007

297. Which characteristic is NOT shared by both Giant Cells and Syncytia?
(A) Being multinucleate
(B) Mechanism of achieving the multinucleate state
(C) Dense, metabolic cytoplasm
(D) Function as a nutritional sink

2018

298. The structural features of a mature, functional syncytium include all EXCEPT:
(A) Cell wall ingrowths
(B) Dissolved internal cell walls
(C) Complete suberization of the entire internal membrane
(D) Numerous enlarged nuclei

2004

299. Most appropriate statement regarding the ultimate fate of the syncytium:
(A) It develops into a new root organ.
(B) It becomes a secondary root meristem.
(C) It turns into a cluster of xylem vessels.
(D) It senesces and dies shortly after the female nematode completes feeding and dies.

2019

300. Correct summary of the physiological goal of establishing a specialized metabolic sink:
(A) To reroute photoassimilates to satisfy parasite nutritional demand.
(B) To increase the plant's overall photosynthetic response.
(C) To store metabolic waste from the nematode.
(D) To produce lipids for the plant root.

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is necessary for these organisms to move and maintain their position within the dense, viscous environments found inside their animal or plant hosts.

37. (A) Aqueous solution of proteins, metabolites, and inorganic ions
The pseudocoelomic fluid is a complex aqueous solution that fills the body cavity of nematodes. It contains various proteins, metabolic intermediates, nutrients, and inorganic ions. This fluid is under high pressure and acts as a hydrostatic skeleton, maintaining the nematode's body shape and providing a medium for the transport of molecules between different tissues in the absence of a circulatory system.

38. (C) Hydrostatic skeleton
The principal biomechanical role of the pseudocoelomic fluid is to function as a hydrostatic skeleton. Because the fluid is essentially incompressible, the high internal pressure it exerts against the flexible but resilient cuticle maintains the nematode's cylindrical shape. This pressure provides the necessary turgor for longitudinal muscles to act against, enabling the undulatory movements required for locomotion through media.

39. (A) It is completely lined by mesodermal epithelium.
The pseudocoelom is a persistent blastocoel-derived body cavity that is not completely lined by mesodermal epithelium, which distinguishes it from a true coelom. It maintains high internal hydrostatic pressure and facilitates the internal transport of nutrients and metabolic wastes. Nematodes lack a heart or independent circulatory organ, so they rely on body movements to circulate fluid within this cavity.

40. (A) I, II and IV
Maintaining high hydrostatic pressure in the pseudocoelom is vital for nematode function. This is achieved through the structural resistance of the cuticle and the continuous contraction of somatic muscles against the internal fluid. Additionally, the excretory system plays a role in regulating the fluid volume. The intestine, however, is a tube passing through the cavity and does not pump fluid out.

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41. (B) Trehalose - Circulates to provide systemic stress protection
Trehalose is a key solute that circulates within the pseudocoelomic fluid of many nematodes. It functions as a mobilizable energy source and a systemic stress protectant, especially during environmental fluctuations. While some nematodes possess hemoglobin, it is not universal. Cellulases are generally sequestered in the esophageal glands, and ascarosides are signaling molecules that may be released externally rather than stored.

42. (C) Loss of structural turgor and locomotory failure
If a nematode's body wall is punctured, the high internal hydrostatic pressure causes the immediate expulsion of the pseudocoelomic fluid. This loss of fluid results in a catastrophic drop in turgor pressure, leading to the collapse of the hydrostatic skeleton. Consequently, the nematode loses its structural integrity and its ability to move, as the muscles no longer have a pressurized medium.

43. (D) Possesses a muscular pharynx to pump food inwards
The high internal hydrostatic pressure of the pseudocoelom presents a challenge for feeding, as the internal cavity would naturally force the digestive tract shut. To overcome this, nematodes possess a powerful muscular pharynx that acts as a pump. This organ generates sufficient pressure to force food and liquid into the intestine against the opposing pressure of the body cavity, ensuring continuous nutrition.

44. (A) Direct perception of environmental chemical signals
The pseudocoelomic fluid is critical for maintaining body shape, distributing nutrients, and transferring mechanical forces during movement. However, the direct perception of environmental chemical signals is primarily the function of the sensory neurons in the amphids and phasmids. These sensors interface directly with the external environment through cuticular pores and do not rely on the internal fluid for initial signal perception.

45. (B) I, II, III and V
The pseudocoelomic fluid serves multiple essential functions in nematode physiology. It acts as a lubricant for internal organs, facilitates

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9. (B) Ectodermal non-cellular secretion
From a developmental and histological perspective, the nematode cuticle is classified as a non-cellular secretion of ectodermal origin. It is synthesized and deposited by the hypodermis, a cellular layer derived from the embryonic ectoderm. This extracellular matrix covers the entire exterior of the body, as well as the linings of the foregut and hindgut, providing a protective barrier.

10. (D) A is false but R is true.
The nematode cuticle was historically viewed as metabolically inert, but it is now recognized as a dynamic structure. It is periodically shed and replaced during the four larval moults to accommodate growth, a process known as ecdysis. While the cuticle itself is an extracellular secretion, the underlying hypodermis remains highly active in synthesizing new components throughout development.

11. (D) Microvilli for nutrient absorption
The nematode cuticle features various structural adaptations like annulations, which provide flexibility, and longitudinal alae, which assist in locomotion. However, microvilli are not found on the cuticle; they are specialized projections of the intestinal epithelial cells designed to increase the surface area for nutrient absorption. The cuticle instead functions as a protective and mechanical interface with environment.

12. (A) Continuously secreted by glandular cells and hypodermis
The surface coat is a thin, dynamic layer of glycoconjugates that covers the nematode epicuticle. It is continuously secreted by the underlying hypodermis and specialized glandular cells, such as the secretory-excretory system. This constant renewal allows the nematode to modify its surface properties rapidly, which is especially important for parasitic species to evade host immune detection and toxins.

13. (B) Lipid
Lipids serve as the primary long-term energy reserve in nematodes, especially during periods of prolonged starvation or environmental stress. They provide the highest energy yield per unit mass compared to proteins or carbohydrates. These fat stores are systematically utilized through beta-oxidation to maintain essential metabolic functions when external food sources are unavailable, ensuring the survival of various life stages.

14. (B) Intestinal epithelium
In many nematodes, particularly non-parasitic and free-living species, the intestinal epithelium is the principal site for lipid storage. Large droplets of neutral lipids, such as triacylglycerols, are sequestered within these cells. This localized storage allows for efficient mobilization of energy reserves directly into the pseudocoelom, where they can be transported to muscles and other tissues for use.

15. (A) It provides readily mobilizable energy for muscle contraction.
Glycogen is a branched polymer of glucose that serves as a readily mobilizable energy source in nematodes. It is primarily stored in the somatic muscles and non-contractile portions of muscle cells. During active movement or sudden energy demands, glycogen is rapidly broken down through glycogenolysis, providing the necessary fuel for muscle contraction and other high-intensity physiological processes.

16. (C) Trehalose is a reducing sugar that quickly reacts with proteins.
Trehalose is a non-reducing disaccharide composed of two glucose molecules. Unlike reducing sugars, it does not react with proteins to cause glycation, making it an ideal stress protectant. It plays a vital role in stabilizing cellular membranes and proteins during desiccation or freezing. Levels of trehalose typically increase significantly when nematodes encounter environmental stressors, providing essential cellular protection.

17. (D) Glycogen - Immediate energy for somatic muscles
Glycogen and lipids represent the two major energy reserves in nematodes. While lipids are used for long-term storage, glycogen provides immediate energy for somatic muscles. It is highly concentrated in the sarcoplasm of muscle cells, where it can be quickly converted to ATP through glycolysis. This immediate availability is crucial for maintaining the undulatory movement required for environmental navigation.

18. (C) Fermentation to ethanol
Aerobic nematodes typically utilize glycolysis, the tricarboxylic acid cycle, and beta-oxidation to meet their energy requirements. These pathways

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efficiently convert carbohydrates and lipids into ATP in the presence of oxygen. While some anaerobic parasites produce specialized organic acids like succinate or acetate, the fermentation of sugars into ethanol is not a typical metabolic pathway used by nematodes.

19. (B) Cryptobiotic survival
Trehalose-6-phosphate synthase is the key enzyme responsible for the biosynthesis of trehalose. Increased activity of this enzyme indicates that the nematode is actively accumulating trehalose as a compatible solute. This biochemical response is a hallmark of preparation for cryptobiotic survival, such as anhydrobiosis, where trehalose acts as a chemical chaperone to protect cellular structures from extreme dehydration.

20. (A) P-3, Q-4, R-1, S-2
Lipids constitute the main long-term storage of energy due to their high caloric density. Glycogen is a branched glucose polymer stored in muscles for rapid mobilization. Trehalose is a non-reducing disaccharide that functions as a critical stress protectant. Glucose acts as a primary monosaccharide intermediate in central metabolic pathways, serving as a precursor for both energy and reserve.

21. (A) Form trehalose from fat stores during embryogenesis
The glyoxylate cycle is a metabolic pathway that allows nematodes to convert lipid reserves into carbohydrates. This process is particularly active during embryogenesis and dauer formation. By bypassing parts of the TCA cycle, nematodes can synthesize glucose and trehalose from acetate derived from fat stores. This conversion is essential for maintaining osmotic balance and providing energy during starvation.

22. (C) Alpha-linked disaccharide of glucose
Biochemically, trehalose is classified as an alpha-linked disaccharide formed by a 1,1-glycosidic bond between two alpha-glucose units. This unique linkage results in a non-reducing sugar that is exceptionally stable at high temperatures and low pH. Its structural properties allow it to form a glass-like state upon dehydration, protecting essential biological macromolecules from the damaging effects of water loss.

23. (A) Cellulase
Lipases, glycogen phosphorylases, and trehalases are essential enzymes for the mobilization of primary energy reserves like lipids, glycogen, and trehalose, respectively. These enzymes break down storage molecules into usable metabolic intermediates. Cellulases, however, are used for the degradation of plant cell walls during feeding and are not involved in the internal mobilization of the nematode's own energy reserves.

24. (D) Lipids provide the highest energy yield per unit mass.
Utilizing lipids as the primary energy reserve offers significant adaptive advantages for nematodes. Lipids are highly reduced molecules and provide more than twice the energy yield per unit mass compared to carbohydrates or proteins. This high energy density allows nematodes to store large amounts of fuel in a compact form, which is critical for survival during extended periods of dormancy.

25. (B) A continuous layer of numerous small muscle cells
The holomyarian arrangement is a specific type of somatic muscle architecture in nematodes. In this configuration, the muscle cells are numerous and relatively small, forming a nearly continuous and uniform layer beneath the hypodermis. This arrangement is distinct from the meromyarian type, which has few cells per quadrant, and the polymyarian type, which features many cells projecting into pseudocoelom.

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26. (C) Muscle arms extend to the nerve cords to form synapses.
A unique feature of nematode physiology is the structure of their neuromuscular junctions. Unlike most other animals, where nerve axons extend to the muscles, nematode muscle cells possess specialized cytoplasmic extensions called muscle arms. These arms reach out to the dorsal or ventral nerve cords to form synapses with the motor neurons. This configuration is essential for coordinating movement.

27. (D) It features two to five large muscle cells per quadrant.
Meromyarian muscle architecture is characterized by a very small number of muscle cells per body quadrant, typically ranging from two to five. This arrangement is commonly found in small, free-living nematodes like Caenorhabditis elegans.

The cells are usually flat and plate-like, with the contractile fibrillar zone located directly against the hypodermis, providing the necessary force for simple movement.

28. (A) They are arranged in circular layers around the intestine.
Nematode somatic muscle cells are arranged exclusively in longitudinal bands rather than circular layers. They are obliquely striated and consist of a contractile fibrillar spindle and a non-contractile sarcoplasmic belly. These cells extend muscle arms toward the nerve cords for innervation. The absence of circular muscles is a defining characteristic that limits the nematode's ability to change its body diameter.

29. (B) Polymyarian - Numerous cells per quadrant projecting into the pseudocoelom
Nematode muscle arrangements are categorized by the number and shape of cells per quadrant. Polymyarian nematodes have numerous muscle cells that project deeply into the pseudocoelom, providing powerful contractions suitable for larger species. In contrast, the meromyarian type has few cells per quadrant, and the holomyarian type features a continuous layer of many small cells. These arrangements dictate locomotory efficiency.

30. (A) I and II
Polymyarian nematodes are defined by having many muscle cells per quadrant, a feature often seen in large parasitic species. Meromyarian nematodes, like many free-living forms, possess only two to five cells per quadrant. While these muscles are striated, they are specifically obliquely striated rather than being purely cross-striated or smooth, which is an adaptation for efficient longitudinal body contraction.

31. (A) Flaccid paralysis of the somatic muscles
Acetylcholine is the primary excitatory neurotransmitter at the nematode neuromuscular junction. When a chemical competitively blocks the acetylcholine receptors on the muscle arms, the muscle cells cannot receive excitatory signals from the motor neurons. This results in the inability of the muscles to contract, leading to flaccid paralysis and a complete loss of the nematode's ability to move or maintain turgor.

32. (C) Smoother and more graded longitudinal contractions
The obliquely striated nature of nematode somatic muscles is a specialized adaptation for longitudinal contraction. In this arrangement, the thick and thin filaments are organized at an angle to the longitudinal axis of the cell. This allows for smoother and more graded contractions compared to cross-striated muscles, facilitating the characteristic undulatory waves that propel the nematode through fluid or soil.

33. (D) Exclusively longitudinal
From a functional mechanics perspective, nematode somatic muscles are classified as exclusively longitudinal. The body wall lacks the circular muscle layers found in many other worms, such as annelids. This anatomical limitation means that nematodes can only bend their bodies dorsally and ventrally. They rely on the antagonism between longitudinal muscles and the internal hydrostatic pressure to achieve sinusoidal locomotion.

34. (C) Intercalated disc
A typical nematode somatic muscle cell consists of a contractile fibrillar zone, a non-contractile sarcoplasmic belly containing the nucleus, and an innervation process known as a muscle arm. Intercalated discs are specialized structures found only in the cardiac muscle of vertebrates and are entirely absent in nematodes. The unique muscle arm extension is the defining feature of nematode somatic architecture.

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35. (D) IV
Platymyarian and coelomyarian are terms used to describe the arrangement of fibrils within a single muscle cell. Fibrils in platymyarian cells are only on the hypodermal side, while in coelomyarian cells they extend up the sides. Circomyarian cells have fibrils surrounding the sarcoplasm. Polymyarian refers to the high number of cells per quadrant, not the shape of individual somatic cells.

36. (D) It provides greater force for movement in dense host tissues.
Large parasitic nematodes often exhibit a polymyarian muscle arrangement, characterized by dozens of muscle cells per quadrant that project into the pseudocoelom. This increased number of cells provides greater contractile force and mechanical power. Such an adaptation

the parasite can actively manipulate the host's immune system, suppressing inflammatory responses and preventing the activation of cellular defenses, which is essential for the successful establishment and maintenance of the infection in a host.

73. (B) Ammonia
Ammonia is the primary nitrogenous waste product excreted by aquatic and many soil-dwelling nematodes. As a product of protein catabolism, ammonia is highly toxic if it accumulates internally. However, because it is also highly soluble in water, it can be easily and rapidly eliminated by diffusion through the body wall or via the excretory pore into the surrounding moist environment.

74. (C) It is highly soluble and diffuses easily into the surrounding water.
The excretion of ammonia is highly advantageous for aquatic organisms because it requires minimal metabolic energy to produce compared to urea or uric acid. Since ammonia is highly soluble in water and has a small molecular size, it diffuses effortlessly through the nematode's cuticle into the surrounding aqueous medium. This constant removal prevents toxic levels from building up within the organism.

75. (A) P-2, Q-1, R-4, S-3
Aquatic nematodes are strictly ammonotelic, relying on the rapid diffusion of ammonia into the water. Terrestrial nematodes under water stress may increase urea production, as urea is less toxic than ammonia. In the host intestine, species like Ascaris excrete a mix of ammonia and urea. During starvation, total nitrogen excretion is generally reduced to conserve internal protein and energy stores.

76. (A) The enzymes of the ornithine-urea cycle are present in some species for urea synthesis.
While ammonia is the main nitrogenous waste, some nematode species also excrete urea. These organisms possess the enzymes of the ornithine-urea cycle, allowing them to synthesize urea from ammonia. Urea is less toxic and can be accumulated at higher concentrations than ammonia, which provides a physiological advantage in environments where water for the diffusion of ammonia is limited for disposal.

77. (B) Nitrogenous wastes are completely converted to solid uric acid pellets.
Nematodes primarily eliminate nitrogenous waste as ammonia or urea through diffusion across the body wall and expulsion via the excretory pore. The intestine also participates in nitrogenous waste elimination. However, nematodes do not convert their nitrogenous wastes into solid uric acid pellets. Uricotely is a strategy used by some insects and reptiles to conserve water, which is not characteristic.

78. (B) Ureotelic - Excreting primarily urea
Animals are classified based on their primary nitrogenous waste product. Ureotelic organisms are those that excrete nitrogen primarily in the form of urea. While most nematodes are predominantly ammonotelic, some exhibit ureotelism under specific environmental conditions or life stages. Uricotelic organisms excrete uric acid, and ammonotelic organisms excrete ammonia. Understanding these strategies is key to studying nematode environmental adaptations.

79. (A) Ammonia toxicity leading to neurological and physiological dysfunction
If a nematode is trapped in a small volume of water, its excreted ammonia will quickly reach toxic levels in the environment. This accumulation prevents further diffusion of ammonia out of the body, leading to internal ammonia toxicity. This condition causes severe neurological and physiological dysfunction, as high ammonia levels disrupt pH balance, enzyme activity, and the function of the nervous system.

80. (P-2, Q-4, R-1, S-3) (A) P-2, Q-4, R-1, S-3
Ammonia is primarily eliminated by direct diffusion across the cuticle and body wall. The excretory pore is the site where waste-laden fluid from the secretory-excretory system is expelled. Undigested nitrogenous matter from the diet is removed via the intestine and anus. Intracellular protein degradation, which produces these wastes, occurs within lysosomes and other metabolic compartments of the internal cells.

81. (D) Environments with some degree of moisture to facilitate diffusion
Nematodes lack the ability to excrete concentrated solid wastes like uric acid, which requires significant water conservation. Consequently, they rely heavily on the diffusion of soluble

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the transport of endocrine signaling molecules, and assists in gas exchange throughout the body. Additionally, it helps buffer the organism against rapid changes in external osmolarity. However, the synthesis of cuticular collagens is a primary function of the hypodermis, not the fluid.

46. (B) Blastocoel-derived cavity lacking complete mesodermal lining
Morphologically, the nematode body cavity is classified as a pseudocoelom because it is derived from the embryonic blastocoel and lacks a complete lining of mesodermal cells. Unlike a true coelom, which is entirely enclosed by peritoneum, the pseudocoelom is bounded by the hypodermis on the outside and the endoderm of the intestine on the inside, serving as a simplified circulatory space.

47. (A) Erythrocytes
The pseudocoelomic fluid is a complex medium containing amino acids, organic acids, and various inorganic cations like sodium and potassium. However, nematodes lack a true circulatory system with specialized blood cells like erythrocytes. Oxygen transport, when necessary, is managed by high-affinity hemoglobins dissolved directly in the fluid or within specific tissues, rather than being sequestered in red blood cells.

48. (C) Continuous body movements thoroughly mix the internal fluids.
Transport within the pseudocoelom is remarkably efficient despite the absence of a heart or ciliary lining. This rapid mixing of internal fluids is achieved primarily through the continuous undulatory movements of the nematode's body. As the organism thrashes or glides, the resulting physical agitation ensures that nutrients, hormones, and metabolic wastes are quickly distributed throughout the cavity to the various tissues.

49. (D) Rapid excretion of excess water via the excretory system
Nematodes living in hypotonic soil environments, where the external water potential is higher than their internal fluid, face a continuous influx of water. To prevent swelling and lysis, they utilize their secretory-excretory system to actively remove excess water. The renette cell or tubular canal system collects the fluid from the pseudocoelom and expels it through the ventral excretory pore.

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50. (C) They accumulate compatible solutes like glycerol and trehalose to balance osmolarity.
When nematodes encounter hypertonic soil solutions, they risk losing internal water to the environment. To adapt, they accumulate compatible solutes, such as glycerol and trehalose, within their cells and pseudocoelomic fluid. These osmoprotectants increase the internal osmotic pressure without damaging proteins, allowing the nematode to maintain hydration and prevent cellular shrinkage in high-salinity or drying conditions in soil.

51. (A) I and II
The renette cell and the associated tubular system are the primary organs for osmoregulation in nematodes, functioning to collect and expel excess fluid. The intestine also plays a significant role in maintaining ion balance by regulating the absorption and secretion of salts. However, the amphids are primarily sensory organs and do not function as active pumps for water excretion during stress.

52. (D) Shrinkage followed by intracellular accumulation of osmoprotectants
Transferring a nematode to a drying or high-salinity environment initially causes water to leave the body due to the osmotic gradient. This results in an immediate shrinkage of the organism. Following this initial phase, the nematode activates stress-response pathways to synthesize and accumulate intracellular osmoprotectants like trehalose and glycerol, which help restore osmotic balance and protect cellular components from desiccation.

53. (A) It serves as the primary exit for solid digestive waste.
The excretory-secretory pore is a specialized opening usually located on the ventral side of the anterior region. It is the exit point for the tubular or glandular excretory system and functions in osmoregulation and the secretion of metabolic products. It is not the site for eliminating solid digestive waste; that function is performed exclusively by the anus at the posterior end.

54. (C) Maintenance of appropriate pseudocoelomic ionic concentrations
The hypodermis is a metabolically active layer that facilitates the exchange of ions between the nematode and its environment. Active ion transport mechanisms within the hypodermis

are essential for maintaining the appropriate ionic composition of the pseudocoelomic fluid. By regulating the concentrations of cations and anions, the hypodermis ensures a stable internal environment necessary for proper neural and muscular function.

55. (A) Water efflux → Shrinkage → Solute synthesis → Volume recovery
Upon entering a hyperosmotic environment, a nematode first experiences water efflux, leading to visible body shrinkage. To counter this, the organism initiates the synthesis of compatible solutes. As these solutes accumulate internally, they lower the internal water potential, eventually allowing for water re-entry and volume recovery. This adaptive sequence is critical for survival in fluctuating soil conditions or high-salinity habitats.

56. (D) Free fatty acids
Nematodes utilize several small organic molecules as compatible solutes to regulate their internal osmotic pressure. Common examples include the disaccharide trehalose, the polyol glycerol, and the amino acid proline. These molecules are non-toxic even at high concentrations. Free fatty acids, however, are not used as osmolytes; they serve primarily as precursors for lipid synthesis or as fuel for energy.

57. (B) Hypertonic stress - Accumulation of compatible osmolytes
Nematodes adapt to varying osmotic pressures by modulating their internal solute concentrations. In hypertonic environments, where external salt concentrations are high, nematodes accumulate compatible osmolytes like trehalose and glycerol to prevent dehydration. This biochemical adjustment balances the osmotic gradient and protects cellular proteins. Conversely, in hypotonic stress, the organism must focus on expelling excess water rather than synthesizing these solutes.

58. (C) Euryhaline osmoregulators
Many nematodes, especially those inhabiting soil or intertidal zones, are classified as euryhaline osmoregulators. They possess the physiological flexibility to tolerate a wide range of external salinities. This is achieved by actively regulating their internal osmotic pressure through the synthesis of compatible solutes or the excretion of excess water, allowing them to remain active despite the fluctuating solute concentrations in environment.

59. (D) Activation of flame cells
Nematodes employ various strategies to survive varying soil solutes, including behavioral avoidance of extreme gradients and modulating the rate of excretory fluid expulsion. They can also alter cuticular permeability to limit water loss. However, they do not possess flame cells; these are specialized excretory structures characteristic of flatworms. Nematodes instead rely on renette cells or tubular secretory-excretory systems for fluid management.

60. (B) Pseudocoelom → Canal → Excretory duct → Excretory pore
In nematodes with a tubular secretory-excretory system, fluid is collected from the pseudocoelom through the walls of the longitudinal canals. These canals run along the length of the body within the lateral hypodermal chords. The collected fluid then travels through the transverse canal to the excretory duct, which is lined with cuticle, and is finally expelled via the ventral pore.

61. (B) A complex H-shaped tubular system
The secretory-excretory system of Secernentean nematodes is characterized by a complex tubular architecture. This often takes the form of an H-shaped or U-shaped system consisting of two longitudinal canals embedded in the lateral hypodermal chords. These canals are connected by a transverse bridge and empty into a common excretory duct, providing an efficient mechanism for osmoregulation in terrestrial environments.

62. (B) A large ventral glandular cell involved in excretion/secretion
The renette cell is a large, specialized glandular cell typically found in the anterior ventral region of Enoplean nematodes. It serves as the primary organ for excretion and secretion, lacking the extensive canal systems seen in more advanced groups. The renette cell collects waste and excess fluid from the pseudocoelom and expels it through a duct leading to the ventral pore.

63. (A) It consists of longitudinal canals embedded in the lateral hypodermal chords.
The H-shaped excretory system is a hallmark of many advanced nematodes. It consists of two longitudinal canals that are situated within the lateral hypodermal chords, extending along most

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of the body length. These canals are joined by a transverse commissure near the anterior end, which connects to a single excretory duct. This arrangement maximizes the surface area for fluid collection throughout.

64. (C) It is responsible for the phagocytosis of invading bacteria.
The secretory-excretory system is multifunctional, playing key roles in osmoregulation, secretion of the surface coat, and the release of digestive enzymes in plant-parasitic species. However, it is not responsible for phagocytosis. Phagocytic functions in nematodes are generally handled by specialized cells called coelomocytes, which circulate within the pseudocoelomic fluid to sequester foreign particles and maintain internal health.

65. (A) Both A and R are true and R is the correct explanation of A.
The H-shaped tubular system is considered an evolutionary advancement over the simpler, unicellular renette cell. By extending longitudinal canals throughout the body, the tubular system provides a much larger surface area for the efficient collection of waste and the regulation of internal fluids. This increased capacity for osmoregulation is particularly advantageous for nematodes living in terrestrial or highly variable habitats.

66. (C) Excretory duct - Lined with cuticle
The secretory-excretory system contains several distinct parts. The terminal excretory duct is a critical component that is lined with cuticle, ensuring it remains open despite high internal pressure. The excretory sinus or transverse canal connects the longitudinal canals to this duct. Note that lateral chords house these canals, while the ventral nerve cord is separate and located in the ventral chord.

67. (B) Inability of fluid from one longitudinal canal to reach the excretory duct
In an H-shaped excretory system, the transverse canal serves as the vital bridge connecting the two longitudinal canals to the central excretory duct. If this transverse canal is blocked, the fluid collected by the longitudinal canals cannot reach the exit point. This leads to a failure in fluid expulsion and osmoregulation, causing the accumulation of metabolic wastes and potentially fatal internal pressure.

68. (D) Structural integrity during high-pressure fluid expulsion
The terminal portion of the excretory system, known as the excretory duct, is lined with a layer of cuticle continuous with the external body wall. This lining is crucial because it provides the structural integrity needed to withstand the high internal hydrostatic pressure of the pseudocoelom. It ensures that the duct remains patent during the active expulsion of fluid and secretory products.

69. (A) Exchange of respiratory gases
The secretory-excretory system in nematodes is a versatile organ involved in osmoregulation, the excretion of metabolic wastes like ammonia, and the secretion of various mucins and enzymes. However, it does not function in the exchange of respiratory gases. Oxygen and carbon dioxide exchange occurs through direct diffusion across the general body wall and cuticle, as nematodes lack specialized respiratory organs.

70. (A) Both A and R are true and R is the correct explanation of A.
Secernentean nematodes generally possess a more complex tubular excretory system compared to the glandular renette cells found in most Enopleans. The development of longitudinal canals allows for a vastly increased surface area for the collection of internal fluids and metabolic by-products. This structural complexity facilitates more precise regulation of internal homeostasis, which is essential for survival in diverse and challenging environments.

71. (A) Unicellular ventral gland
Morphologically, the renette cell is classified as a large, unicellular ventral gland. It is the ancestral form of the excretory system in nematodes and is primarily responsible for both the secretion of specific proteins and the excretion of excess water and ions. While it may have associated ducts, it lacks the extensive multinucleated or syncytial tubular networks seen in more complex species.

72. (D) Releasing immunomodulatory compounds into the host
In animal-parasitic nematodes, the secretory-excretory system contains numerous secretory granules. These granules are used to release various immunomodulatory compounds into the host's environment. By secreting these molecules,

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ANSWERS

1. (D) Collagen
The nematode cuticle is a complex multi-layered structure secreted by the hypodermis. The basal layer, which is the innermost zone of the cuticle, is primarily composed of collagen proteins. These collagens are extensively cross-linked via disulfide bonds to provide structural integrity and flexibility, acting as a functional antagonist to the high internal hydrostatic pressure of the pseudocoelom.

2. (C) Evasion of host immune responses
Parasitic nematodes possess a dynamic surface coat primarily composed of glycoconjugates like mucins and glycoproteins. This external layer serves as a critical interface between the parasite and its host. By continuously shedding and renewing these molecules, the nematode can effectively mask its presence, neutralize host antibodies, and circumvent cellular immune responses, thereby ensuring successful long-term survival.

3. (B) They form cross-linked, non-collagenous structural networks.
Cuticlins represent a distinct class of non-collagenous proteins found within the nematode cuticle, particularly in the epicuticle and cortical layers. Unlike collagens, they are highly insoluble and resistant to most enzymatic degradation. They form stable, cross-linked structural networks that contribute significantly to the mechanical strength and chemical resistance of the exoskeleton, providing essential protection against environmental stresses.

4. (D) It is composed mainly of living, nucleated cells.
The nematode cuticle is an extracellular, non-cellular secretion produced by the underlying cellular hypodermis. It is composed of multiple layers of proteins, primarily collagens and cuticlins, rather than living cells. This rigid yet flexible structure functions as a hydrostatic skeleton antagonist, facilitating locomotion while simultaneously protecting the internal organs and restricting the organism's radial expansion during growth phases.

5. (A) Median layer - Struts and fluid-filled spaces in some species
The nematode cuticle exhibits a complex architecture traditionally divided into several zones. The median layer is situated between the cortical and basal zones and often displays specialized structural features. In many species, this layer contains vertical pillars or struts separated by fluid-filled spaces. These adaptations provide structural support while maintaining the flexibility necessary for the characteristic undulatory movement.

6. (C) Chitin
Chitin is a major component of fungal cell walls and arthropod exoskeletons but is notably absent from the nematode cuticle. Instead, the nematode exoskeleton relies on collagens and cuticlins for structural support. While chitin is found in the eggshell and some internal structures like the pharynx, it does not constitute a primary structural element of the cuticle.

7. (A) Loss of cuticular elasticity and hydrostatic integrity
Collagens in the nematode cuticle are stabilized by extensive disulfide cross-linking, which is essential for maintaining the structure's mechanical properties. Disruption of these bonds leads to a loss of cuticular elasticity and structural integrity. Without this support, the cuticle cannot effectively oppose the internal hydrostatic pressure, resulting in severe locomotory failure and physical deformation of the body.

8. (D) Enhanced mechanical strength and resistance
Extensive disulfide bonding between cysteine residues in cuticular collagens is a defining biochemical feature of the nematode exoskeleton. This process facilitates the formation of a rigid, stable protein matrix. These cross-links directly enhance the mechanical strength and chemical resistance of the cuticle, allowing the organism to withstand environmental stresses and maintain the internal pressure necessary for its hydrostatic skeleton.

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ammonia. This physiological constraint limits most nematodes to environments with at least a thin film of moisture. This water is necessary to act as a sink for the continuous diffusion and removal of toxic by-products.

82. (C) Exhalation via specialized spiracles
Nematodes eliminate nitrogenous wastes through several pathways, including diffusion across the cuticle, expulsion via the secretory-excretory pore, and defecation of undigested matter through the anus. However, they do not possess specialized respiratory spiracles or a tracheal system for "exhaling" wastes. Spiracles are characteristic of the respiratory systems of insects, whereas nematodes rely entirely on cutaneous gas exchange and fluid excretion.

83. (B) Nitrogenase
Nematode nitrogen metabolism involve enzymes like arginase and urease for urea processing, and glutamate dehydrogenase for managing ammonia. Nitrogenase, however, is an enzyme found exclusively in certain bacteria and archaea that are capable of fixing atmospheric nitrogen into ammonia. Nematodes cannot fix nitrogen and must obtain it through their diet, so they lack the genetic machinery for nitrogenase synthesis.

84. (D) The soil pore water provides a sufficient aqueous sink for diffusion.
Despite living in soil, terrestrial nematodes continue to rely heavily on ammonia excretion. This is possible because the thin films of water surrounding soil particles provide a sufficient aqueous sink for the diffusion of ammonia away from the nematode's body. As long as the soil remains moist, this strategy is energetically efficient and effective for preventing the accumulation of toxic wastes.

85. (B) I and III
In aerobic nematodes, energy generation occurs through the same fundamental processes as in other metazoans. The tricarboxylic acid (TCA) cycle operates within the mitochondria to oxidize metabolic intermediates. This is coupled with an electron transport chain where cytochrome c oxidase serves as the terminal electron acceptor, facilitating the production of a high yield of ATP per glucose molecule during respiration.

86. (C) The Embden-Meyerhof-Parnas pathway and TCA cycle
Fully aerobic nematodes utilize standard metabolic pathways to meet their energy needs. This includes the Embden-Meyerhof-Parnas pathway (glycolysis) to break down glucose into pyruvate, followed by the TCA cycle in the mitochondria for complete oxidation. These pathways mirror those found in higher metazoans, allowing nematodes to efficiently harvest energy from carbohydrates and lipids in the presence of environmental oxygen.

87. (A) They utilize a modified electron transport chain with rhodoquinone.
Parasitic nematodes like Ascaris inhabit low-oxygen environments such as the host intestine. They have adapted by utilizing a modified mitochondrial electron transport chain. In this pathway, rhodoquinone replaces ubiquinone as the electron carrier, and fumarate acts as the terminal electron acceptor instead of oxygen. This allows for anaerobic energy production through a process known as malate dismutation for survival.

88. (D) Nematodes utilize specialized hemolymph vessels for oxygen transport.
Nematodes lack specialized respiratory organs like gills or lungs, as well as a heart and vascular system for oxygen transport. Instead, gas exchange occurs through direct diffusion across the general body wall and cuticle. While some species produce high-affinity hemoglobins to scavenge oxygen from their surroundings, they do not have hemolymph vessels to distribute these gases through the body.

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89. (B) Hypoxia in intestine - Phosphoenolpyruvate (PEP) carboxykinase pathway activation
In hypoxic conditions, such as those found in the host intestine, nematodes activate the phosphoenolpyruvate (PEP) carboxykinase pathway. This pathway diverts PEP from the normal aerobic glycolytic route toward the production of oxaloacetate and then malate. This is a critical adaptation for anaerobic metabolism, allowing the nematode to continue energy production by utilizing malate as a substrate for mitochondrial fermentation.

90. (A) I, II and III
Anaerobic metabolism in many parasitic nematodes involves several key adaptations.

which innervate the somatic muscles. In contrast, the dorsal nerve cord is mainly composed of axons and is primarily involved in motor control of the dorsal muscles. The circumpharyngeal ring serves as the integration center for sensory and motor signals.

127. (A) Paralysis of the body muscles posterior to the lesion
The ventral nerve cord is essential for coordinating the motor activity of the somatic muscles. A lesion that completely severs this cord posterior to the nerve ring would interrupt the flow of motor signals from the central processing center. This would result in the paralysis of all somatic muscles located posterior to the site of the injury, effectively ending the nematode's ability to move.

128. (C) A highly stereotyped and mapped neural connectome
The deterministic cell lineage of nematodes ensures that every individual of a species develops a highly stereotyped and identical nervous system. Because the fate of every precursor cell is fixed, the resulting neural connectome is precisely mapped and consistent across the entire population. This lack of variability is a significant advantage for researchers using nematodes to study fundamental principles of neurobiology.

129. (D) Bilaterally symmetrical with a circumpharyngeal ring and longitudinal cords
The nematode nervous system is classified as bilaterally symmetrical. It features a prominent circumpharyngeal nerve ring in the head region, which serves as the central brain. From this ring, several longitudinal nerve cords, most notably the dorsal and ventral cords, extend along the length of the body. These cords are linked by transverse commissures, creating a ladder-like but unsegmented architecture.

130. (D) A is false but R is true.
While myelin is a characteristic of vertebrate and some invertebrate nervous systems, providing rapid saltatory conduction, it is entirely absent in nematodes. Nematode axons are non-myelinated and relatively small. Consequently, signal conduction is slower and relies on different physiological mechanisms. Despite this lack of myelin, the nematode nervous system is highly efficient at coordinating complex behaviors through its precisely mapped connectome.

131. (B) Medial
Nematodes possess four primary longitudinal nerve cords: the dorsal cord, the ventral cord, and two lateral cords. The dorsal and ventral cords are the most prominent and are primarily involved in motor control of the somatic muscles. The lateral cords are largely sensory. There is no recognized medial nerve cord in the standard anatomical description of the nematode nervous system.

132. (D) Complex integration at the nerve ring regulating behavior
Neural processing in nematodes involves complex integration at the circumpharyngeal nerve ring. This structure receives sensory inputs from various receptors and processes this information to regulate complex behavioral outputs, such as chemotaxis, foraging, and mating. While simple reflexes do exist, the nerve ring acts as a sophisticated central integration hub that allows the nematode to navigate and respond to its environment.

133. (A) Acetylcholine (ACh)
Acetylcholine is the primary excitatory neurotransmitter at the nematode neuromuscular junction. When released by motor neurons, it binds to nicotinic acetylcholine receptors on the muscle arms, triggering muscle contraction. This excitatory signaling is essential for the generation of the power strokes required for locomotion. The level of acetylcholine is carefully regulated by the enzyme acetylcholinesterase to ensure proper motor control.

134. (C) Gamma-aminobutyric acid (GABA)
Gamma-aminobutyric acid (GABA) is the principal inhibitory neurotransmitter in the nematode nervous system. It is released by specialized inhibitory motor neurons and acts on GABA receptors on the muscle cells. Binding of GABA typically leads to an influx of chloride ions, which hyperpolarizes the muscle cell membrane. this results in muscle relaxation, a process vital for coordinating the alternating waves of locomotion.

135. (A) P-2, Q-1, R-3, S-4
Acetylcholine serves as the primary excitatory neurotransmitter at the neuromuscular junction,

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99. (B) They are injected into host tissues via the stylet.
Esophageal gland secretions are critical for the parasitic life cycle of many nematodes. These proteins, often referred to as effectors, are synthesized within the glands and then actively injected into the host tissues through the hollow, needle-like stylet. This delivery mechanism allows the nematode to manipulate host physiology and degrade plant structural components directly at the site of feeding or migration.

100. (A) I, II, III and IV
Digestion in nematodes involves both extracellular and intracellular phases. Secreted enzymes initiate the breakdown of host tissues or food particles in the pharynx or external environment. Following ingestion, smaller molecules are taken up by the intestinal epithelium, where intracellular digestion is completed within lysosomes. The stylet serves as a conduit for these secretions, while pectinases are used to macerate tissues.

101. (A) Cellulase - Plant cellulose microfibrils
Plant-parasitic nematodes produce specific enzymes to overcome host barriers. Cellulases are designed to target and degrade the cellulose microfibrils that provide structural strength to the plant cell wall. Pectate lyases target pectin, and proteases target proteins. Each of these enzymes plays a specialized role in softening the host tissue and facilitating the nematode's movement and nutrient acquisition from plant.

102. (C) Fail to penetrate and migrate through the plant roots
If a plant expresses a cellulase inhibitor, it targets the enzymes the nematode uses to degrade host cell walls. Cellulases are vital for the nematode's ability to penetrate the root surface and migrate through the cortical cells. Inhibiting these enzymes effectively prevents the nematode from navigating the plant tissue, thereby blocking the establishment of a feeding site and protecting plant.

103. (A) Suction of liquid food into the digestive tract
The median bulb is a muscular, valve-like structure in the nematode esophagus. Its rapid, rhythmic pumping action creates a powerful suction that draws liquid food and nutrients from the host or environment through the stylet and into the digestive tract. This mechanism is essential for efficient ingestion, especially for sedentary parasites that must continuously acquire nutrients from specialized feeding sites.

104. (D) Secretion of osmoregulatory compatible solutes
The esophageal glands of nematodes are specialized for the synthesis and secretion of effector proteins, including various cell-wall-degrading enzymes like cellulases and pectinases. These secretions are vital for plant parasitism. However, the production of osmoregulatory compatible solutes is a systemic physiological process managed by the hypodermis and the secretory-excretory system, rather than being a function of the esophageal glands.

105. (A) III and V
Plant-parasitic nematodes possess a fully functional intestine for nutrient absorption and have acquired cell-wall-degrading enzymes (CWDEs), likely through horizontal gene transfer. These enzymes are characteristic of phytoparasitic species and are not found in animal-parasitic nematodes. The dorsal and subventral glands are correctly identified by their emptying points, which are crucial for the delivery of secretions during infection.

106. (C) Phytoparasitism
The utilization of cell-wall-degrading enzymes is the hallmark of phytoparasitism in nematodes. These enzymes allow the organism to overcome the structural barriers of the plant cell wall, which is composed of cellulose, hemicellulose, and pectin. By secreting these proteins, plant-parasitic nematodes can penetrate roots, migrate through tissues, and establish the specialized feeding sites necessary for their development and reproduction.

107. (D) Phagocytosis by epidermal cells
Phytoparasitic feeding is a complex process involving the mechanical thrusting of the stylet, the secretion of effector proteins, and the muscular pumping of the pharynx to ingest nutrients. However, phagocytosis by epidermal cells is not a component of this process. In nematodes, nutrient uptake occurs exclusively through the digestive tract, where the intestinal epithelium absorbs digested molecules across the microvillar brush border.

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Rhodoquinone is used in the electron transport chain, and fumarate serves as the terminal electron acceptor. This process results in the accumulation and excretion of succinate as a major end-product. While these adaptations allow survival without oxygen, they are significantly less efficient than aerobic respiration, yielding less ATP.

91. (D) Cessation of anaerobic ATP production and parasite death
In the anaerobic mitochondria of Ascaris suum, fumarate reductase is the essential enzyme that reduces fumarate to succinate, coupled with ATP synthesis. Inhibiting this enzyme blocks the terminal step of the parasite's specialized anaerobic electron transport chain. This leads to a complete cessation of ATP production under anaerobic conditions, resulting in the rapid metabolic failure and death of the parasite.

92. (A) Facilitate oxygen diffusion to tissues despite low external partial pressure
Some nematodes produce specialized hemoglobins with extremely high oxygen affinity. These proteins allow the organism to scavenge oxygen even when it is present at very low partial pressures in their environment. By binding oxygen tightly, these hemoglobins facilitate its diffusion into deeper tissues, ensuring that aerobic metabolic processes can continue even in niches that are nearly anoxic, such as host tissues.

93. (B) Facultative anaerobic relying on malate dismutation
Adult Ascaris living in the host intestine function as facultative anaerobes. They primarily rely on a specialized metabolic process called malate dismutation for energy production. This involves the simultaneous oxidation and reduction of malate within the mitochondria to produce ATP, with succinate and volatile fatty acids as the major end-products. This allows the parasite to thrive in the low-oxygen environment.

94. (B) Uric acid
During anaerobic metabolism, nematodes produce and excrete various organic molecules as end-products. Common products include succinate, propionate, and acetate, which are derived from the fermentation of carbohydrates. Uric acid, however, is a nitrogenous waste product associated with protein metabolism in some animals and is not an end-product of the anaerobic pathways used by nematodes for energy generation.

95. (A) I, II and IV
The PEP carboxykinase pathway is a major metabolic adaptation for anaerobic life in nematodes. It diverts phosphoenolpyruvate away from the pyruvate kinase step of glycolysis, converting it instead to oxaloacetate. This oxaloacetate is then reduced to malate, which enters the mitochondria to serve as a substrate for anaerobic energy production. This pathway is most active in low-oxygen environments.

96. (C) Ability to switch between aerobic TCA cycle and anaerobic malate dismutation depending on environmental oxygen.
Nematodes exhibit significant flexibility in their intermediary metabolism. Many species have the ability to switch between the aerobic TCA cycle and specialized anaerobic pathways, such as malate dismutation, depending on the availability of environmental oxygen. This metabolic plasticity allows them to survive and remain active during transitions between different hosts or environmental niches with varying oxygen concentrations.

97. (D) Subventral and dorsal esophageal glands
In plant-parasitic nematodes, the subventral and dorsal esophageal glands are the primary sites for the synthesis of cell-wall-degrading enzymes. These three large, specialized cells are highly active during the infection process. The enzymes produced here are packaged into secretory granules and transported through the gland ducts to be injected into the host plant tissue via the hollow oral stylet.

98. (C) Beta-1,4-endoglucanase (Cellulase)
Cyst nematodes and many other plant parasites secrete beta-1,4-endoglucanases, commonly known as cellulases, from their esophageal glands. These enzymes are essential for the degradation of cellulose microfibrils in the plant cell wall. By breaking down these structural components, the nematode can more easily penetrate the root tissue and migrate to its permanent feeding site, facilitating a successful parasitic relationship.

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117. (A) Midgut
Anatomically, the nematode intestine is classified as the midgut. It is a straight, non-muscular tube that extends from the esophagus to the rectum. The midgut is the primary site for both the final stages of digestion and the absorption of nutrients. It is distinguished from the foregut and hindgut by its endodermal origin and the absence of a cuticular lining.

118. (C) Primary synthesis of acetylcholine for the nervous system
The nematode intestinal epithelium is a multifunctional tissue responsible for nutrient digestion, the absorption of metabolic products, and the storage of energy reserves like lipids and glycogen. It also participates in some aspects of waste excretion. However, it is not the primary site for the synthesis of neurotransmitters like acetylcholine, which are produced within the neurons of the nervous system.

119. (A) Myofibrils
Active absorptive intestinal cells are packed with organelles that support their metabolic and transport functions, including mitochondria for energy, and endoplasmic reticulum and Golgi for protein and lipid synthesis. However, myofibrils, which are the contractile elements of muscle cells, are not abundant in the intestinal epithelium. These cells lack a muscular wall and rely on body movements to move food.

120. (A) Stylet → Median bulb → Intestine → Rectum → Anus
Food particles ingested by a plant-parasitic nematode follow a linear path through the digestive system. They are first drawn through the hollow stylet by the suction of the muscular median bulb. From the esophagus, the food enters the intestine for digestion and absorption. Remaining undigested waste then passes into the rectum and is finally expelled from the body through the anus.

121. (B) Circumpharyngeal nerve ring
The circumpharyngeal nerve ring is the central processing organ of the nematode nervous system. Often referred to as the nematode brain, it is a dense ring of neuropil that surrounds the esophagus in the anterior region. This structure integrates sensory information from the amphids and other receptors, coordinating the organism's motor output and complex behavioral responses through the longitudinal nerve cords.

122. (C) Containing both motor and sensory fibers
The ventral nerve cord is the largest and most complex longitudinal nerve in the nematode body. It is functionally characterized by its dual role, containing both motor and sensory fibers. It houses many of the motor neuron cell bodies and coordinates the movement of the somatic muscles. It also acts as a primary conduit for sensory information traveling toward the circumpharyngeal nerve ring.

123. (D) It consists primarily of neuropil and associated ganglia.
The circumpharyngeal nerve ring is located in the anterior portion of the nematode, wrapping around the pharynx. It is not composed of a single axon but is a complex structure consisting primarily of a dense neuropil formed by the axons and dendrites of numerous neurons. Associated with various ganglia, it serves as the primary site for neural integration and behavioral control.

124. (D) The nerve ring wraps around the intestine.
The nematode central nervous system consists of a nerve ring and longitudinal cords that process sensory input and coordinate movement. The dorsal nerve cord is primarily motor, while the ventral cord is both motor and sensory. These cords are connected by several commissures. However, the nerve ring wraps around the esophagus, not the intestine, which is located more posteriorly.

125. (A) Both A and R are true and R is the correct explanation of A.
The nematode nervous system is a classic example of eutely, where the total number of neurons is constant within a species. In Caenorhabditis elegans, the adult hermaphrodite possesses exactly 302 neurons. This fixed cellular architecture has allowed for the complete mapping of its neural connectome, providing a detailed understanding of how specific neurons and their synaptic connections govern organism's behavior.

126. (B) Ventral nerve cord - Contains motor neuron cell bodies
The ventral nerve cord is the primary longitudinal bundle in the nematode nervous system. It contains the cell bodies of most motor neurons,

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pseudocoelomic fluid and cytoplasm but is not sequestered in synaptic vesicles.

144. (C) They are neuropeptides modulating various behavioral outputs.
FMRFamide-like peptides (FLPs) are a diverse family of neuropeptides that are widely distributed throughout the nematode nervous system. They act as potent neuromodulators, fine-tuning various physiological and behavioral outputs such as locomotion, feeding, and reproduction. By binding to specific G-protein coupled receptors, FLPs play a critical role in the complex coordination of the nematode's response to its internal and external environment.

145. (A) I and III
Nematode locomotion is powered by the contraction of longitudinal muscles against the incompressible pseudocoelomic fluid. This high-pressure fluid acts as a hydrostatic skeleton, maintaining the body's turgor. The flexible cuticle serves as the essential antagonist to muscle contraction, providing the elastic restoring force needed to return the body to its original shape. Nematodes lack circular muscles, which dictates unique movement.

146. (C) Undulatory locomotion (sinusoidal waves)
The typical form of propulsion for most nematodes is undulatory locomotion, characterized by sinusoidal waves passing along the body. This movement is generated by alternating contractions of the dorsal and ventral longitudinal muscle bands. This strategy is highly effective for moving through the thin films of water found in soil pores or within the viscous fluids of a host's internal environment.

147. (B) Waves of contraction pass anteroposteriorly along the dorsal and ventral longitudinal muscles alternately.
Nematode movement is generated by waves of muscle contraction that pass along the body from the anterior to the posterior end. These contractions alternate between the dorsal and ventral longitudinal muscle bands. This alternating pattern creates the characteristic sinusoidal curves that push against the surrounding environment, such as soil particles or fluid, resulting in efficient forward or backward progression in soil.

148. (D) It actively generates ATP for muscle fibers.
The hydrostatic skeleton is fundamental to nematode biomechanics, providing structural support, transmitting mechanical forces, and acting as an antagonist to muscle contraction. It ensures the body maintains its shape under high pressure. However, the hydrostatic skeleton is a physical system and does not actively generate ATP; energy production is a biochemical process occurring within the mitochondria of the internal cells.

149. (A) Antagonist - Internal hydrostatic pressure and cuticular elasticity
In the biomechanical system of a nematode, the internal hydrostatic pressure and the elastic cuticle act together as the antagonist to the longitudinal muscle contractions. Because nematodes lack circular muscles, they rely on this internal pressure to restore the body's shape after each contraction. Forward movement is achieved by propagating undulatory waves from the head toward the tail, leveraging environment.

150. (A) I and II
Nematode locomotion is significantly influenced by the physical properties of the environment. In low-viscosity fluids, nematodes often slip and thrash inefficiently because they lack sufficient leverage. In contrast, the particulate nature of soil provides necessary fulcra, or leverage points, which allow the nematode to translate its undulatory waves into efficient forward motion. This highlights the adaptation of nematodes to soil-dwelling life.

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151. (A) Thrash continuously without significant forward progression
If a nematode is placed in a completely frictionless liquid, it will be unable to generate any forward progression. Despite the continuous undulatory contractions of its longitudinal muscles, the lack of external resistance or particulate matter means there is no substrate to push against. The nematode will merely thrash its body in place, illustrating the dependency of its locomotory system on friction.

152. (D) They cannot easily alter their body diameter.
The absence of circular somatic muscles is a fundamental anatomical feature of nematodes. This limitation means that they cannot perform the peristaltic contractions seen in other worms like earthworms. Consequently, nematodes

while GABA provides inhibitory control. Serotonin acts as a key neuromodulator, specifically regulating feeding behavior and egg laying in response to food availability. Octopamine is involved in modulating stress responses and locomotion. Together, these molecules coordinate the complex physiological and behavioral responses of the nematode to its environment.

136. (D) Dopamine and serotonin modulate complex behaviors like learning and mating.
Biogenic amines, such as dopamine and serotonin, play critical roles as neuromodulators in the nematode nervous system. These molecules are synthesized internally by specific sets of neurons and are not simply metabolic waste. They function to modulate complex behaviors, including learning, foraging, and mating. By altering the sensitivity of neural circuits, biogenic amines allow nematodes to adapt behavior to environment.

137. (B) The muscle cells synthesize their own ACh to auto-stimulate.
In nematode neuromuscular transmission, motor neurons release neurotransmitters across synapses located on the muscle arms. Acetylcholine induces contraction, and its signal is terminated by acetylcholinesterase. GABA causes muscle relaxation. However, muscle cells do not synthesize their own acetylcholine to auto-stimulate; they depend entirely on the precise release of neurotransmitters from the axonal processes of the nerve cords for contraction.

138. (C) Ivermectin - Glutamate-gated chloride channel activator
Ivermectin is a powerful anthelmintic that works by acting as an agonist for glutamate-gated chloride channels. These channels are primarily found in the nerves and muscles of nematodes. Activation by ivermectin leads to a continuous influx of chloride ions, causing hyperpolarization and resulting in flaccid paralysis of the parasite. This specific mechanism of action makes it highly effective against many nematodes.

139. (D) Spastic paralysis due to continuous ACh stimulation
Acetylcholinesterase (AChE) is the enzyme responsible for breaking down the excitatory neurotransmitter acetylcholine in the synaptic cleft. If an AChE inhibitor is applied, acetylcholine persists at the neuromuscular junction, causing continuous and excessive stimulation of the muscle receptors. This leads to a state of spastic paralysis, where the muscles are permanently contracted and the nematode is unable to move or feed.

140. (A) P-4, Q-1, R-2, S-3
Ivermectin acts as a glutamate-gated chloride channel activator, leading to flaccid paralysis. Levamisole is an acetylcholine agonist that causes spastic paralysis by overstimulating muscles. Aldicarb is an acetylcholinesterase inhibitor that also results in spastic paralysis. Piperazine functions as a GABA agonist, causing muscle relaxation and flaccid paralysis. These compounds target specific components of the nematode nervous system for anthelmintic effects.

141. (B) Relaxation of the opposing muscles, enabling smooth undulatory movement
During undulatory locomotion, the release of GABA onto the muscles on the opposite side of a contraction is essential. This inhibitory signaling causes those contralateral muscles to relax. By ensuring that one side of the body relaxes while the other contracts, GABA enables the formation of the smooth, alternating sinusoidal waves that are the hallmark of nematode movement through soil and fluids.

142. (B) Melatonin
Nematodes utilize several biogenic amines for neural signaling, including serotonin, dopamine, and histamine, which modulate behaviors such as feeding, movement, and sensory perception. Melatonin, while a common biogenic amine in vertebrates involved in circadian rhythms, is not a recognized neurotransmitter in the standard nematode nervous system. Their behavior is primarily governed by the balance of excitatory and inhibitory signaling from other amines.

143. (A) Trehalose
Nematode synaptic vesicles are specialized for storing and releasing various signaling molecules, including classical neurotransmitters like acetylcholine and GABA, as well as FMRFamide-like neuropeptides. These molecules are essential for rapid neural communication. Trehalose, however, is a sugar used for energy storage and stress protection. It is found in the

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detecting organs found in some aquatic species, and cephalic papillae, which are primarily mechanosensory. Phasmids are posterior chemosensors. Together, these organs provide the nematode with a sophisticated sensory suite to detect chemical, mechanical, and light-based cues.

162. (C) Lose its ability to locate host plant roots
The amphids are essential for the chemosensory perception required for host location. If the amphidial sensilla of an infective juvenile root-knot nematode are destroyed, the organism will lose its ability to detect and follow the chemical gradients produced by host plant roots. Consequently, the nematode will be unable to navigate toward its food source, leading to starvation and eventual death.

163. (B) Protect ciliated dendrites and facilitate chemical transport
The amphidial sheath cells secrete a viscous, mucus-like fluid into the amphidial pouch and duct. This secretion serves several critical functions: it protects the delicate ciliated dendrites of the sensory neurons from the external environment and facilitates the transport and binding of chemical signaling molecules. This specialized medium ensures the efficient and sensitive detection of environmental cues by the chemoreceptors.

164. (D) Modified ciliated dendrites
The sensory neurons within the amphids are classified as having modified ciliated dendrites. These specialized terminal structures are where the chemoreceptors are located. The presence of these cilia is a universal feature of nematode sensory neurons, although their internal microtubule arrangement can vary from the standard 9+2 axoneme. These dendrites extend into the amphidial duct to interface with the chemical environment.

165. (A) I and III
A typical nematode sensillum is a complex unit consisting of one or more sensory neurons along with two specialized glial cells: the socket cell and the sheath cell. The sensory dendrite extends into the sensillum structure. The sheath cell is responsible for secreting the mucus-like fluid that surrounds the dendrite, while the socket cell forms the opening to the external cuticle.

166. (C) Malpighian cell
A nematode sensillum is composed of three main cellular components: the sensory dendrite of a neuron, the sheath cell that provides metabolic support and secretions, and the socket cell that anchors the structure to the cuticle. Malpighian cells are not found in nematodes; they are part of the excretory system of insects. Nematodes use distinct cell types for sensory and excretory.

167. (A) Synthesizing digestive enzymes for the intestine
Nematode sensory physiology is essential for identifying potential mates, avoiding harmful chemicals, and detecting host plants. These functions are mediated by various chemosensory and mechanosensory organs. However, the synthesis of digestive enzymes for the intestine is a metabolic function performed by the esophageal glands and intestinal epithelium, and is not a direct role of the organism's sensory perception or neural center.

168. (D) Amphids are anterior and phasmids are posterior.
The most significant distinction between amphids and phasmids is their anatomical location on the nematode body. Amphids are always located in the anterior head region and are the primary chemosensors. Phasmids are located in the lateral tail region and also have a chemosensory function. While their structures are similar, their placement allows for spatial sampling of chemical cues from different body directions.

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169. (B) Spatial and temporal sampling using their amphidial receptors
Nematodes detect concentration gradients of host exudates through a process of spatial and temporal sampling. As the nematode moves, its amphidial receptors continuously measure the levels of specific chemical attractants. By comparing these measurements over time or between slight movements of the head, the nematode can determine the direction of the source and navigate toward the root tip of host.

170. (B) I and II
During navigation, nematodes move toward higher concentrations of attractants. If they sense they are moving away from the source, their turning frequency increases, allowing them to reorient themselves. This behavior, known as chemotaxis, is governed by the integration of

are unable to significantly alter their body diameter or length. Instead, they are restricted to undulatory movements produced by the longitudinal muscles acting against the internal hydrostatic skeleton.

153. (B) Hydrostatic skeleton system
The physical system that enables nematode locomotion is classified as a hydrostatic skeleton. This system relies on the high pressure of the incompressible pseudocoelomic fluid contained within the flexible but tough cuticle. By contracting longitudinal muscles against this pressurized fluid, the nematode can generate the force needed for movement while maintaining a consistent cylindrical body shape, even without skeleton.

154. (C) Presence of rigid jointed appendages
Efficient undulatory locomotion in soil is dependent on several factors, including the precise coordination of dorsal and ventral muscle contractions and the presence of internal hydrostatic pressure. The surface tension of water films in the soil also provides necessary traction. However, nematodes do not possess any rigid jointed appendages; their movement is entirely based on the bending of the body.

155. (B) I and II
The muscle contraction cycle in nematodes begins when depolarization of the cell membrane opens calcium channels, leading to an increase in intracellular calcium. This triggers the sliding of actin and myosin filaments past each other within the fibrillar zone, resulting in the shortening of the muscle cell. This mechanical force is then transmitted through the cell structure to the cuticle.

156. (A) Simultaneous contraction would shorten the body without locomotion.
Undulatory waves in nematodes must alternate between the dorsal and ventral muscle bands to achieve effective locomotion. If all longitudinal muscles contracted at once, the nematode would simply shorten its body without generating any directional movement. By alternating contractions, the nematode creates the characteristic curves that allow it to push against the environment and propel itself forward or backward efficiently.

157. (B) Amphids
The amphids are the primary anterior chemosensory organs of nematodes. These complex, paired sensory structures are located in the head region and open to the exterior through small pores. They contain numerous specialized sensory neurons that detect a wide range of chemical signals, including host-secreted attractants, pheromones, and environmental cues, playing a vital role in navigation and host finding.

158. (B) Lateral tail region
Phasmids are specialized sensory organs located in the lateral tail region of many nematodes, particularly those in the class Chromadorea. Like the anterior amphids, phasmids are chemosensory in nature and open to the external environment through pores. They are believed to function in detecting chemical signals in the nematode's surroundings, potentially assisting in social behaviors or avoiding harmful substances in soil.

159. (A) They consist of a pore, a duct, a pouch, and ciliated sensory neurons.
Amphids are complex sensory structures composed of an external pore, a duct, a pouch, and several specialized neurons with ciliated dendrites. They are the primary chemosensory organs, allowing nematodes to detect and respond to various chemical stimuli in their environment. These organs are nearly universal among nematodes, highlighting their fundamental importance for foraging, mating, and the identification of suitable hosts.

160. (B) I and II
Amphidial neurons are primarily located in the anterior head region and are essential for sensing chemical gradients. They allow the nematode to perform chemotaxis by detecting and processing information about attractants and repellents. These neurons are integrated into the central nervous system but are not directly connected to the midgut. Their specialized ciliated dendrites are the site where signal transduction occurs.

161. (D) Amphids - Primary olfactory/chemosensory organs
Amphids are the primary olfactory and chemosensory organs in nematodes, essential for environmental navigation. Other sensory structures include ocelli, which are simple light-

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108. (A) Represents horizontal gene transfer events that enabled plant parasitism.
The presence of endogenous cell-wall-degrading enzymes in nematodes is of immense evolutionary significance. These genes are believed to have been acquired from soil bacteria or fungi through horizontal gene transfer. This acquisition provided ancestral nematodes with the biochemical tools necessary to degrade plant cell walls, representing a pivotal event that enabled the transition to and diversification of the plant-parasitic lifestyle.

109. (B) Microvillar brush border
The luminal surface of the nematode intestinal epithelium is characterized by the presence of a dense microvillar brush border. These microscopic, finger-like projections significantly increase the available surface area for the absorption of nutrients from the intestinal lumen. This structural adaptation is essential for maximizing the efficiency of nutrient uptake into the intestinal cells, where further processing and storage occur.

110. (A) I and V
The nematode intestine is a simple tube composed of a single layer of epithelial cells and lacks a muscular wall. The apical surface of these cells features microvilli for nutrient absorption. Contrary to some other parts of the digestive tract, the midgut is not lined with a cuticular or chitinous layer. This lack of a cuticle facilitates the direct transport of nutrients into cells.

111. (A) The microvilli significantly increase the surface area for absorption.
Nutrient absorption in the nematode intestine is highly efficient due to the presence of microvilli on the apical surface of the epithelial cells. These structures provide a vast surface area for the action of membrane-bound enzymes and transport proteins. Nutrients are moved from the lumen across this brush border into the cell cytoplasm, where they can be utilized or stored for later.

112. (C) They are ectodermal in origin.
Intestinal epithelial cells in nematodes are highly active in the metabolism and storage of lipids and glycogen. They possess a well-developed set of organelles, including a prominent nucleus and mitochondria. While the foregut and hindgut are ectodermal in origin, the midgut (intestine) is derived from the embryonic endoderm. These cells have a basolateral membrane that interfaces with the pseudocoelomic fluid.

113. (D) Terminal web - Anchors microvilli and maintains cellular integrity
The terminal web is a specialized cytoskeletal structure located just beneath the apical plasma membrane of intestinal cells. It consists of a dense network of filaments that anchor the microvilli and maintain the structural integrity of the brush border. This organization is essential for the cell's absorptive function and provides mechanical stability to the luminal surface of the intestinal epithelium.

114. (C) Severe starvation due to absorption failure
Damage to the microvillar brush border would severely impair the nematode's ability to absorb nutrients from its food. Since the brush border provides the necessary surface area and transport mechanisms for nutrient uptake, its loss leads to profound metabolic deficiency. This results in severe starvation, even if the nematode continues to feed, eventually causing a decline in health, reproduction, and survival.

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115. (A) Lumen → Apical membrane → Cytoplasm → Basolateral membrane → Pseudocoelom
During absorption, nutrients follow a specific pathway through the intestinal epithelium. They move from the intestinal lumen across the apical microvillar membrane and into the cell cytoplasm. After metabolic processing or storage, these molecules are transported across the basolateral membrane. Finally, they enter the pseudocoelomic fluid, which distributes them throughout the body to provide energy for other tissues.

116. (D) Intracellular digestion of macromolecules occurs after endocytosis
The abundance of lysosomes in nematode intestinal cells indicates that intracellular digestion is a primary metabolic process. After macromolecules are taken up from the lumen via endocytosis, they are sequestered into vesicles that fuse with lysosomes. The hydrolytic enzymes within the lysosomes then break down these complex molecules into simpler nutrients, which are subsequently released into the cytoplasm for use.

signals from the amphidial neurons. Ocelli are not used for this process; they are light-sensitive organs found only in certain nematode species.

171. (D) Specific carbon compounds and metabolites act as attractants.
Root exudate perception is a highly specific process. Plants release a complex mixture of carbon compounds and metabolites into the soil, and specific molecules within this mixture act as attractants for particular nematode species. These chemical cues are detected by the amphidial chemoreceptors, which then trigger the neural and motor responses necessary for the nematode to locate and infect plant roots.

172. (A) Repellents trigger an immediate halt to all movement forever.
Chemotaxis involves movement toward or away from chemical sources. Positive chemotaxis is movement toward an attractant. A pirouette is a specialized behavior where the nematode makes a sudden, large-angle turn to reorient its direction. While repellents cause the nematode to move away from a source, they do not trigger an immediate or permanent halt to all movement by the organism forever.

173. (B) GPCR - Cell surface receptor for chemical cues
G-protein coupled receptors (GPCRs) are the primary cell surface receptors responsible for detecting chemical cues in the nematode's environment. These receptors are densely packed within the membranes of the amphidial sensory neurons. When an attractant binds to a GPCR, it initiates an internal signaling cascade that ultimately leads to the generation of a neural impulse, coordinating the navigational behavior of nematode.

174. (B) Failure to transduce chemosensory signals, leading to chemotaxis defects
The TAX-2 and TAX-4 proteins form essential cyclic nucleotide-gated ion channels within the amphidial sensory neurons. These channels are critical for transducing chemosensory signals into electrical impulses. A mutation that disables these channels will prevent the nematode from responding to environmental chemical cues. This leads to profound chemotaxis defects, leaving the nematode unable to find food, mates, or plant hosts.

175. (A) I, II, III, IV
The process of chemosensory transduction follows a precise sequence. It begins with the binding of a ligand, such as a root attractant, to a specific receptor on the sensory neuron. This event triggers the opening of ion channels, leading to a change in the membrane potential. This electrical signal is then transmitted to the nerve ring, where it is integrated.

176. (C) Increases, allowing the nematode to reorient back up the gradient
The pirouette model explains how nematodes navigate chemical gradients. According to this model, the probability of the nematode performing a sudden reorientation turn, or pirouette, increases as the concentration of an attractant decreases. By turning more frequently when moving away from a source, the nematode is more likely to reorient itself back toward the direction of the increasing chemical gradient in soil.

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177. (D) G-protein coupled receptors (GPCRs)
The primary receptors responsible for olfaction and chemoreception in nematodes are G-protein coupled receptors (GPCRs). Nematodes, such as C. elegans, possess hundreds of different GPCR genes, allowing them to detect an immense variety of chemical molecules in their environment. These receptors are located on the specialized ciliated dendrites of the sensory neurons, where they initiate the signal transduction pathways for navigation.

178. (C) Complex structural lignins
Plant root exudates are rich in small molecules like carbon dioxide, amino acids, and sugars, which serve as potent attractants for phytoparasitic nematodes. However, complex structural lignins are highly insoluble and are part of the internal structural framework of the plant. They are not typically released in a form that would act as a diffusible chemical signal for nematodes navigating through soil.

179. (B) Rhodopsin-mediated phototransduction
Nematode chemosensory pathways are complex and involve olfactory GPCRs, G-proteins, and calcium signaling to transduce environmental signals into neural activity. While nematodes can detect light, they do not use rhodopsin-mediated phototransduction in the same way vertebrates do; instead, they utilize different types of

receptors, such as LITE-1. These pathways are specialized for different sensory modalities, ensuring environmental perception.

180. (A) I and III
The interaction with host exudates begins when specific chemical molecules are detected by the sensory cilia of the amphidial neurons. This signal is processed and transmitted to the central nervous system. The subsequent motor response, which guides the nematode toward the host, is coordinated by the ventral nerve cord and associated motor neurons. The sheath cell provides structural and metabolic support.

181. (A) A strictly predictable pattern of cell divisions in embryos
Deterministic cell lineage is a fundamental developmental principle in nematodes. It refers to the strictly predictable pattern of cell divisions that occurs from the single-cell zygote to the adult. Every cell division is invariant, meaning that each precursor cell always gives rise to the same specific tissues and organs in every individual of a given species, ensuring complete developmental consistency.

182. (C) Adults have a constant, species-specific number of somatic cells.
Eutely, or cell constancy, is the biological principle where an adult organism has a fixed and species-specific number of somatic cells. In nematodes, this means that once the adult stage is reached, somatic cell division ceases. Growth in the adult is achieved through the enlargement of existing cells, known as hypertrophy, rather than the addition of new cells, which is characteristic.

183. (A) It produces a somatic founder cell and a germline precursor.
The first cleavage of the nematode zygote is asymmetric and highly significant. It produces two distinct cells: a large anterior somatic founder cell (AB) and a smaller posterior germline precursor cell (P1). This division establishes the primary body axis and separates the lineage that will form most of the body's somatic tissues from the lineage that will eventually produce the gametes.

184. (D) Eutely prevents any form of post-embryonic growth.
Eutely is the state where an adult nematode has a constant number of somatic nuclei, such as the 959 nuclei found in a C. elegans hermaphrodite. While somatic cell division stops, the germline continues to divide to produce gametes. Importantly, eutely does not prevent growth; adult nematodes increase in size primarily through the hypertrophy, or enlargement, of their existing somatic cells.

185. (D) A is false but R is true.
Nematodes possess a very limited capacity for tissue regeneration because their development is governed by a rigid and deterministic cell lineage. Since each cell has a fixed fate and cannot be replaced if lost, any damage to embryonic or somatic cells typically results in permanent defects. The lack of flexible stem cell populations in adult somatic tissues further restricts their ability.

186. (C) AB cell - Primarily gives rise to hypodermis and nervous system
During nematode embryogenesis, specific founder cells give rise to particular tissue lineages. The AB cell is the largest founder cell and primarily produces the hypodermis and the majority of the nervous system. Other cells, like the E cell, produce the intestine, while the MS cell gives rise to muscle and the P4 cell produces the germline. This division ensures development.

187. (D) Be unable to produce gametes.
The P4 cell is the primordial germ cell in the nematode embryo. It is the sole progenitor of the entire germline. If this cell is specifically ablated during early development, the resulting adult nematode will be physically normal in its somatic structures but will completely lack reproductive organs and gametes. This results in a sterile individual that is unable to produce any offspring.

188. (A) Mutations in early founder cells have massive, often lethal, downstream effects
The rigid and deterministic cleavage pattern in nematodes means that the fate of every early embryonic cell is fixed. Because there is no developmental flexibility or cell replacement, any mutation or damage to an early founder cell has massive and often lethal downstream effects on the entire lineage. This ensures that development is fast and consistent but also highly vulnerable to disruption.

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189. (B) Determinate, modified spiral (or rotational) cleavage
Nematode embryonic development is classified as determinate, featuring a modified form of rotational or spiral cleavage. From the very first division, the developmental fate of each daughter cell is established. This pattern is invariant across individuals of a species, leading to the precise and predictable formation of tissues and organs that is a hallmark of the phylum Nematoda development.

190. (C) A is true but R is false.
Somatic cell division in nematodes typically ceases once the organism reaches adulthood, a state known as eutely. From this point forward, any further increase in body size is achieved primarily through the hypertrophy, or enlargement, of existing cells rather than the production of new ones. This means that adult nematodes grow larger without increasing their total number of somatic nuclei.

191. (A) Germ cells (gametes)
While most tissues in an adult nematode follow the rule of eutely and have a fixed cell number, the germline is a notable exception. Germ cells continue to divide throughout the reproductive life of the adult to produce a continuous supply of sperm or oocytes. This allows the nematode to maintain its reproductive capacity even though its somatic tissues have stopped dividing.

192. (C) A precursor cell that gives rise to specific lineages.
A founder cell in nematode embryogenesis is a specific precursor cell that gives rise to a distinct and predictable lineage of tissues. During early development, the zygote divides into several of these founder cells, such as AB, E, and MS. Each of these cells follows a fixed developmental program, ensuring that the correct organs and structures are formed in the embryo.

193. (D) Are amoeboid and lack flagella.
Nematode spermatogenesis produces highly specialized and unique mature spermatozoa. Unlike the flagellated, swimming sperm found in most other animals, nematode sperm are amoeboid and completely lack flagella. They move by crawling with the help of pseudopodia. This movement is powered by the polymerization of Major Sperm Protein (MSP), which provides the necessary motility within the female or hermaphrodite tract.

194. (C) XO (heterogametic with one sex chromosome)
In the XX/XO sex determination system common to many nematodes, sex is determined by the number of X chromosomes. Hermaphrodites or females typically possess two X chromosomes, making them homogametic. Males possess only a single X chromosome and no Y chromosome, making them the heterogametic sex. This simple chromosomal mechanism regulates the development of male-specific or hermaphroditic reproductive structures in species.

195. (A) I and II
Nematode reproduction involves several unique physiological features. Males are often equipped with sclerotized spicules that facilitate copulation by holding the female's vulva open. The sperm are non-flagellated and amoeboid, moving by crawling within the reproductive tract to reach the eggs. Fertilization occurs internally, typically within the uterus or a specialized spermatheca, rather than being released into the external environment.

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196. (D) Maturation and meiotic progression are often triggered by signals from sperm.
Oogenesis in nematodes is a highly organized process. Oocytes develop within the tubular ovary, maturing as they move from the distal end toward the proximal end. In many species, the final stages of oocyte maturation and the progression of meiosis are not spontaneous; they are actively triggered by chemical signals, such as Major Sperm Protein, released by the nearby sperm cells.

197. (A) They swim through the pseudocoelom to reach the ovary.
Nematode sperm are unique amoeboid cells that lack flagella and do not swim through fluid. Instead, they move by crawling along the walls of the reproductive tract using pseudopodia. This motility is driven by the polymerization of Major Sperm Protein rather than actin. They must crawl up the uterus to reach the spermatheca, where fertilization of the oocytes occurs internally.

216. (B) I and II
The regulation of nematode moulting is a complex interplay between the environment and internal physiology. Environmental cues can trigger the release of specific hormones that initiate the cycle. Nuclear hormone receptors are essential for the transcriptional response to these hormones. Importantly, the process is entirely dependent on the hypodermis, which is the cellular layer responsible for all cuticular synthesis.

217. (B) Root exudates containing specific hatching factors
For many specialized plant-parasitic nematodes like the potato cyst nematode, egg hatching is not spontaneous but is triggered by specific chemical signals. These signals, known as hatching factors, are present in the root exudates of host plants. The detection of these factors by the encysted juveniles ensures that hatching occurs only when a suitable host is available nearby in soil.

218. (C) Vitelline, chitinous, and lipid
The nematode eggshell is a multi-layered structure that provides essential protection for the developing embryo. It typically consists of three distinct layers: an outer vitelline layer, a middle chitinous layer that provides structural rigidity, and an inner lipid layer. This lipid layer is particularly important as it serves as a highly impermeable barrier, regulating the exchange of water and solutes.

219. (D) Hatching factors cause structural changes in the lipid layer.
During the hatching process, specialized chemical signals or environmental factors cause significant structural changes in the eggshell's inner lipid layer. This layer, which is normally impermeable, becomes more permeable to water and solutes. This alteration allows the juvenile to hydrate and activate its metabolism, which is a critical physiological step that must occur before the juvenile can physically emerge.

220. (A) Emergence is entirely a passive process driven by osmotic swelling.
Juvenile emergence is a highly active process that requires significant energy and physical effort. It is not merely a passive event driven by osmotic swelling. The juvenile must engage in vigorous muscular activity, including rhythmic body contractions and repeated thrusting of its stylet to weaken and pierce the eggshell. Proteases may also be secreted to help soften the structural layers.

221. (B) Trehalose efflux - Decreases internal osmotic pressure, signaling hatching readiness
Prior to hatching, there is a significant efflux of trehalose from the fluid surrounding the juvenile within the egg. This loss of trehalose decreases the internal osmotic pressure and is a key physiological signal that the juvenile is ready to emerge. This process facilitates the hydration of the juvenile's tissues, triggering the metabolic and muscular activity necessary for the hatching process.

222. (B) Remain dormant in the soil for years
In the absence of the specific hatching factors found in host root exudates, the eggs of specialized parasitic nematodes like cyst nematodes will remain in a state of dormancy. These eggs can persist in the soil for many years, protected by their robust shells and the maternal cyst. They will only hatch when the required host plant is eventually grown.

223. (A) Hydration and activation of the juvenile's metabolism and movement
The loss of trehalose from the egg fluid just before hatching leads to a decrease in the osmotic potential of the surrounding medium. This change results in the hydration of the juvenile's tissues, which is essential for activating its metabolic pathways and muscular systems. Once hydrated, the juvenile becomes vigorous and begins the physical process of breaking through the eggshell to emerge.

224. (C) Obligate host-stimulated hatching
Many specialized nematodes, such as cyst-forming species, exhibit obligate host-stimulated hatching. This means that the eggs will not hatch in significant numbers unless they detect specific chemical signals from a host plant. This evolutionary adaptation ensures that the vulnerable infective juveniles emerge only when there is a high probability of finding and successfully infecting a suitable food source in soil.

225. (D) Massive synthesis of glycogen in the eggshell
The physiology of nematode egg hatching involves complex changes in the permeability of the lipid layer, the secretion of enzymes like proteases

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207. (A) It is dissolved by enzymes secreted by the hypodermis.
During the moulting process, the old cuticle must be separated from the body and partially degraded to facilitate its removal. This is achieved through the action of specific enzymes, such as proteases and chitinases, which are secreted by the underlying hypodermis. These enzymes dissolve the basal and median layers of the old cuticle, allowing the nematode to eventually shed the exoskeleton.

208. (D) It is governed by a random set of genes every time.
The synthesis of the new nematode exoskeleton is a precisely regulated genetic process that occurs after the separation of the old cuticle. The cellular hypodermis is responsible for secreting new structural proteins, primarily collagens and cuticlins. This process is governed by a specific and invariant set of genes at each moult, ensuring the new cuticle has the appropriate physical properties.

209. (D) Lethargus - A period of reduced behavioral activity preceding ecdysis
Lethargus is a critical behavioral phase that occurs just before the shedding of the old cuticle, known as ecdysis. During lethargus, the nematode exhibits a significant reduction in movement and ceases feeding. This period of inactivity coincides with the complex physiological events of synthesizing a new cuticle and degrading the old one, preparing the organism for the final shed.

210. (C) Failure of the old cuticle to degrade, resulting in incomplete ecdysis (moulting block)
Zinc metalloproteases are essential enzymes involved in the degradation of the old cuticular proteins during the moulting cycle. If an inhibitor of these proteases is applied during the lethargus phase, the enzymatic breakdown of the old exoskeleton will be blocked. This prevents the separation and shedding of the old cuticle, resulting in a failure of ecdysis and complete developmental arrest.

211. (B) Hardening and stabilization of the new exoskeleton
Immediately following ecdysis, the new nematode cuticle is soft and flexible. To achieve its final functional state, it undergoes extensive structural modification through tyrosine cross-linking. This biochemical process creates strong covalent bonds between cuticular proteins, causing the exoskeleton to harden and stabilize. This provides the necessary mechanical strength and resistance to support the nematode's hydrostatic skeleton and environmental protection.

212. (D) Ecdysis
Biologically, the process of shedding the old cuticle and emerging in a new one is known as ecdysis. This event is the culmination of the moulting cycle and is common to all members of the Ecdysozoa, including nematodes and arthropods. Ecdysis allows the nematode to overcome the growth limitations imposed by its non-living exoskeleton, enabling it to increase in size.

213. (A) Complete dedifferentiation of the nervous system
The nematode moulting cycle involves the cessation of feeding, the synthesis of a new epicuticle, and the shedding of the old cuticle, including the linings of the esophagus and rectum. However, there is no complete dedifferentiation of the nervous system. The neural architecture remains intact and functional throughout the process, although behavioral activity is significantly reduced during the lethargus period.

214. (C) Ecdysone-like sterols
Hormonal control of the moulting process in nematodes is mediated by signaling molecules that share similarities with those found in other ecdysozoans. These include sterol-based molecules often referred to as ecdysone-like hormones. These hormones bind to nuclear receptors, initiating the complex transcriptional cascade required for the hypodermis to synthesize a new cuticle and orchestrate the transition to the next stage.

215. (A) Permits step-wise growth despite a restrictive exoskeleton.
The primary significance of the moulting process is that it permits step-wise growth in nematodes. Because the cuticular exoskeleton is a relatively rigid, non-living structure, it does not expand continuously. By periodically shedding the old cuticle and secreting a larger one, the nematode can increase its body volume and develop through its juvenile stages toward sexual maturity in the adult.

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234. (C) LEA proteins - Act as molecular chaperones in dry states
Late Embryogenesis Abundant (LEA) proteins are critical biochemical components of the nematode's stress response system. These highly hydrophilic proteins act as molecular chaperones, stabilizing cellular membranes and preventing the aggregation of other proteins during periods of severe dehydration. By maintaining the structural integrity of the cell in a dry state, LEA proteins are essential for successful and long-term anhydrobiotic survival.

235. (A) II, I, III, IV
Entering anhydrobiosis follows a specific physiological sequence. First, the nematode must induce the synthesis of protective molecules like trehalose. This is followed by the gradual loss of body water and the formation of a tight coil to reduce surface area. Finally, the organism enters a state of ametabolism, where all detectable life processes cease, allowing for long-term survival in dry conditions.

236. (A) Mechanical disruption of cellular structures by ice crystals or massive shrinkage
The vitrification ability of trehalose is a key survival mechanism during severe dehydration. As water is lost, trehalose forms a biological glass-like state within the cells. This non-crystalline, solid state prevents the mechanical disruption of cellular structures that would otherwise be caused by ice crystals or excessive shrinkage. This molecular stabilization is essential for preserving the integrity of the nematode's internal organization.

237. (B) Survival of freezing through ice nucleation management and antifreeze synthesis
Cryobiosis is a specialized form of cryptobiosis that allows nematodes to survive at freezing temperatures. This adaptation involves the management of ice nucleation and the synthesis of antifreeze compounds or cryoprotectants like glycerol. These molecules prevent the formation of lethal intracellular ice crystals, protecting the cell membranes and allowing the organism to remain viable in permafrost or other extremely cold soil environments.

238. (B) Immediate, rapid drying in seconds
Successful entry into anhydrobiosis requires a slow and controlled rate of drying, which allows time for the nematode to synthesize protective sugars and undergo morphological coiling. If a nematode is dried too rapidly, it will suffer irreversible structural damage before its protective systems can be fully activated. Therefore, immediate drying in seconds is detrimental and prevents the successful transition to survival.

239. (A) Suffer irreversible membrane damage and die
Trehalose is an indispensable chemical chaperone for surviving desiccation. If a nematode that is genetically incapable of synthesizing trehalose is subjected to drying, it will lack the essential molecular protection needed to stabilize its cell membranes and proteins. Consequently, the organism will suffer irreversible cellular damage and death during the dehydration process, regardless of how slowly the internal water is lost.

240. (A) I, II, III, IV
The process of recovery from anhydrobiosis begins with the absorption of water from the environment. Once the tissues are rehydrated, the nematode resumes its metabolic activity. The protective trehalose stores are then degraded and utilized as an initial energy source. Finally, as internal homeostasis is restored, the nematode regains its muscular coordination and initiates movement, completing its return to metabolic life.

241. (D) Starvation, high population density (dauer pheromone), and high temperature
The formation of the dauer larva is a complex developmental response triggered by several environmental factors. These include a lack of food, high population density as signaled by a specific dauer pheromone, and high ambient temperatures. These cues indicate that the current environment is unfavorable for normal growth and reproduction, prompting the nematode to enter a resistant, developmentally arrested stage.

242. (C) L3
The dauer larva is a specialized, developmentally arrested form that typically occurs as an alternative to the normal third larval stage (L3). When environmental conditions are poor, the nematode diverts from the standard life cycle at the end of the L2 stage to become a dauer. This stage is uniquely adapted for long-term survival and dispersal in harsh environmental conditions.

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and chitinases by the juvenile, and active stylet thrusting. These processes collectively work to weaken the shell and allow emergence. However, the massive synthesis of glycogen within the eggshell is not a component of the physiological hatching mechanism.

226. (C) Absence of any gravitational field
Spontaneous hatching in many non-specialized nematodes is influenced by abiotic environmental factors such as soil moisture, ambient temperature, and soil aeration. These factors provide cues that the external environment is favorable for juvenile survival. However, the presence or absence of a gravitational field is not a recognized physiological stimulus that influences the timing or success of the hatching process for nematodes.

227. (B) It acts as an impermeable barrier protecting the juvenile.
The lipid layer of the nematode eggshell is a critical physiological barrier. Its primary role is to act as an impermeable seal that protects the developing embryo or dormant juvenile from environmental stressors, such as toxic chemicals and desiccation. By controlling the movement of water and solutes, the lipid layer ensures the internal environment remains stable until hatching is actively triggered.

228. (D) Emergence is always synchronized to happen at night.
The mechanics of emergence are driven by both enzymatic and physical processes. Juveniles secrete enzymes from their esophageal glands to help degrade the structural layers of the shell, and they use rhythmic muscle contractions to force their way out. While environmental cues influence hatching, emergence is not synchronized to occur specifically at night; it happens whenever internal and external conditions are met.

229. (A) A temporary, reversible state of suspended animation in response to adverse environmental conditions
Cryptobiosis is a specialized physiological state in nematodes characterized by the temporary and reversible suspension of all detectable metabolic activity. It is an adaptation to survive extreme environmental stresses, such as total desiccation or freezing. In this state of suspended animation, the nematode can remain viable for extended periods, resuming its normal life processes once favorable conditions are eventually restored.

230. (A) Both A and R are true and R is the correct explanation of A.
Anhydrobiotic nematodes can survive for decades in a completely dry state by reducing their metabolic rate to undetectable levels. To protect their cellular integrity, they accumulate large quantities of protective sugars like trehalose and specialized proteins. These molecules stabilize cellular membranes and prevent the damaging effects of dehydration, allowing the organism to remain viable until rehydration eventually occurs.

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231. (A) P-2, Q-1, R-4, S-3
Different types of cryptobiosis allow nematodes to survive specific environmental stresses. Anhydrobiosis is the response to extreme desiccation, while cryobiosis enables survival in freezing temperatures. Anoxybiosis is triggered by a lack of oxygen, and osmobiosis occurs in response to high external salinity. Each of these states involves unique biochemical and physiological adaptations that protect the nematode from potentially lethal environmental conditions.

232. (D) The nematode coils tightly to reduce surface area.
Upon entering anhydrobiosis, many nematodes undergo characteristic morphological changes, such as coiling their bodies tightly. This coiling behavior reduces the total surface area exposed to the environment, which significantly slows down the rate of water loss. This controlled dehydration is essential for the biochemical adjustments needed to protect cellular structures and ensure the successful entry into a stable, dry survival state.

233. (B) Metabolism shifts entirely to rapid aerobic glycolysis.
The biochemistry of nematode survival in extreme conditions involves the accumulation of protective sugars like trehalose and the production of Late Embryogenesis Abundant proteins. These molecules act as chemical chaperones to stabilize cellular components. However, metabolism does not shift to rapid aerobic glycolysis; instead, the metabolic rate drops to nearly zero, ensuring that the organism's energy stores are carefully conserved.

252. (A) Allows populations to survive boom-and-bust cycles and disperse.
The primary evolutionary benefit of the dauer stage is that it allows nematode populations to survive boom-and-bust cycles in their environment. By entering a resistant and long-lived state during unfavorable times, the population can persist until resources return. Furthermore, the dauer stage is specialized for dispersal, increasing the likelihood that the nematode will find and colonize new, productive habitats.

253. (B) Genetic amenability, transparency, and mapped connectome.
Caenorhabditis elegans is a premier biological model due to several unique characteristics. These include its genetic amenability, which allows for easy manipulation of its DNA, and its transparent body, which facilitates live imaging of all internal cells. Furthermore, its developmental cell lineage and the entire neural connectome have been completely mapped, providing an unparalleled level of detail for biological research.

254. (B) Neurobiology and developmental genetics
Sydney Brenner chose C. elegans as a model organism with the primary goal of studying neurobiology and developmental genetics. He recognized that its small number of cells and rapid life cycle made it ideal for understanding how genes control the development of the nervous system and give rise to specific behaviors. This pioneering work established the foundation for modern molecular biology.

255. (A) P-2, Q-4, R-1, S-3
C. elegans is characterized by eutely, meaning it has a constant cell number across individuals. Its transparency is a key feature that facilitates live imaging of cellular processes. Hermaphroditism allows for easy self-fertilization, which is a major advantage for genetic studies. The connectome is a complete map of all its neural synapses, providing a comprehensive view of its entire nervous system.

256. (C) Exactly 131 specific cells undergo programmed death.
The discovery of programmed cell death was a landmark in C. elegans research. During the development of the adult hermaphrodite, exactly 131 specific cells are genetically programmed to undergo death at precise times. This highly invariant process allowed researchers to identify the genes, such as the ced family, that regulate cell death, which are also highly conserved in human biology.

257. (D) The connectome varies significantly between individual wild-type hermaphrodites.
The C. elegans neural connectome is an invariant map of exactly 302 neurons and all their synaptic connections. This precise map is used to study the neural basis of behavior and is consistent across all wild-type individuals of the species. Unlike higher animals, there is no significant variation in the number or connectivity of neurons between individuals, making it a powerful tool.

258. (C) ced genes - Cell death (apoptosis) abnormal
Genetic research in C. elegans has identified many gene families with specific phenotypes. The ced (cell death abnormal) genes are essential for the regulation and execution of programmed cell death. Other common gene classes include unc (uncoordinated) genes affecting movement, daf (dauer formation) genes affecting development, and rol (roller) genes affecting the structure of the cuticle, providing biological insights.

259. (B) Survival of extra cells that normally would have undergone apoptosis
The ced-3 gene encodes an essential caspase that is required for the execution of programmed cell death in C. elegans. If this gene is knocked out, the 131 cells that are normally programmed to die during development will survive. This leads to a phenotype where the nematode has extra cells, which has been critical for understanding the molecular pathways of apoptosis.

260. (A) P-1, Q-2, R-3, S-4
Research on C. elegans has led to multiple Nobel Prizes. Brenner, Horvitz, and Sulston were recognized for their work on the genetic regulation of development and programmed cell death. Fire and Mello received the prize for the discovery of RNA interference (RNAi). Chalfie was honored for the development of Green Fluorescent Protein (GFP) as a vital tool for biological imaging.

261. (A) High-throughput, whole-genome reverse genetics screens
The discovery that RNA interference (RNAi) can be achieved by simply feeding C. elegans bacteria

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243. (B) It forms a specialized, highly impermeable cuticle and a sealed oral opening.
Entering the dauer stage involves significant morphological changes. The nematode develops a specialized, highly impermeable cuticle that provides resistance to desiccation and toxins. The oral opening is sealed, preventing feeding, and the body becomes thinner and more radially constricted. These adaptations are essential for survival during this period of developmental arrest, where the organism focuses on conservation rather than growth.

244. (D) It exhibits a massively increased metabolic rate to find new food.
Dauer larvae are characterized by their ability to survive for long periods without food. They have a sealed buccal cavity and do not feed, relying entirely on stored lipid reserves for their minimal energy needs. Their metabolic rate is significantly decreased, not increased, which allows them to conserve resources. This metabolic depression is a key feature of their enhanced environmental resistance.

245. (A) Both A and R are true and R is the correct explanation of A.
The dauer stage is an alternative to the normal L3 stage in the nematode life cycle. It serves as a facultative survival mechanism that allows the organism to endure adverse environmental conditions, such as starvation or high temperatures. Additionally, the dauer stage is specialized for dispersal, enabling the nematode to wait for better conditions or be transported to new, favorable habitats.

246. (C) DAF-16 (FOXO transcription factor) - Promotes dauer formation when active/nuclear
The decision to enter the dauer stage is regulated by several conserved signaling pathways. The DAF-16 protein, a FOXO-family transcription factor, is a central regulator of this process. When conditions are unfavorable, DAF-16 becomes active and moves into the nucleus, where it promotes the expression of genes required for dauer formation and longevity. This pathway integrates environmental signals for survival.

247. (A) Constitutive dauer formation even in the presence of abundant food (dauer-constitutive)
The daf-2 gene encodes an insulin-like receptor that is a primary regulator of the transition between normal development and the dauer stage. A loss-of-function mutation in daf-2 causes the nematode to behave as if environmental conditions are poor, even when food is abundant. This results in constitutive dauer formation, where all individuals enter the dauer stage regardless of their surroundings.

248. (D) Resistance to harsh external chemicals and desiccation
The sealing of the buccal cavity and the formation of a thickened, specialized cuticle are key adaptations of the dauer stage. These structural modifications provide the nematode with an exceptional level of resistance to external stressors, including harsh chemicals, detergents, and desiccation. This physical barrier ensures the organism remains protected while it is in a state of metabolic arrest and dispersal.

249. (B) Facultative, alternative developmental diapause stage
The dauer stage is classified as a facultative, alternative developmental diapause stage. It is not an obligate part of the life cycle; if environmental conditions are favorable, the nematode will bypass the dauer stage entirely and proceed through normal juvenile development. This flexibility allows the nematode to maximize its reproductive potential in good conditions while maintaining a robust survival strategy for bad.

250. (A) Both A and R are true and R is the correct explanation of A.
Dauer larvae exhibit a significantly increased lifespan compared to normal juveniles. This is because they enter a state of metabolic depression where their energy consumption is minimized and normal aging processes are suspended. As a result, the time spent in the dauer stage does not count toward the nematode's total post-dauer adult lifespan, allowing it to survive for many months.

251. (D) Active feeding and digestion
The dauer stage is characterized by several physiological and morphological adaptations, including radial shrinkage of the body, a shift to specialized lipid metabolism for long-term energy storage, and the suspension of the aging process. However, active feeding and digestion are not part of this stage; the buccal cavity is sealed and the nematode relies entirely on internal energy reserves.

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198. (C) Parthenogenesis - Development of an embryo from an unfertilized egg
Parthenogenesis is a form of asexual reproduction where an embryo develops from an unfertilized egg without the need for sperm. This strategy is common in many nematode species, allowing for rapid population growth in favorable environments. In contrast, syngamy is the fusion of gametes, hermaphroditism involves individuals with both male and female organs, and spermatogenesis produces specialized amoeboid sperm.

199. (A) Sperm will be unable to crawl to the spermatheca, causing sterility.
Major Sperm Protein (MSP) is the essential protein required for the amoeboid motility of nematode sperm. It functions similarly to actin in other cells by polymerizing to form the cytoskeleton of the pseudopodia. If a chemical inhibits the polymerization of MSP, the sperm will be unable to crawl toward the spermatheca. This leads to a failure in fertilization and results in sterility.

200. (A) I, II and III
The nematode gonad is typically a tubular structure that houses the developing germline. At the distal tip of the gonad, a specialized distal tip cell provides a niche that maintains the germline stem cells through signaling pathways. This ensures a continuous supply of cells for gametogenesis. In many nematodes, the germline is the only tissue that continues to divide in adults.

201. (B) Maintenance of a mitotic germline stem cell niche via Notch signaling
The distal tip cell (DTC) is a critical regulatory cell located at the end of the nematode gonad. It maintains a stem cell niche by utilizing Notch signaling to prevent the adjacent germ cells from differentiating. This ensures that a population of mitotic germline cells is preserved throughout the organism's life, allowing for the continuous production of gametes for reproduction.

202. (C) Self-fertilizing hermaphrodites and Males
In Caenorhabditis elegans, the two naturally occurring sexual forms are self-fertilizing hermaphrodites and males. Hermaphrodites are essentially females that produce a limited number of sperm during their early development, which they later use to fertilize their own oocytes. Males occur at a low frequency in the population and are necessary for genetic outcrossing, contributing to the species' overall genetic diversity.

203. (D) Axoneme (9+2 microtubule arrangement)
The nematode spermatozoon is a highly specialized, non-flagellated cell. It features pseudopodia for amoeboid movement, which is powered by Major Sperm Protein, and contains numerous membranous organelles. However, it completely lacks an axoneme, which is the characteristic $9+2$ microtubule arrangement that forms the core of flagella in the swimming sperm of most other animal groups.

204. (A) Fallopian tube
The typical female or hermaphrodite nematode reproductive tract is composed of several specialized regions, including the ovary for egg production, the spermatheca for sperm storage and fertilization, and the uterus for egg development. These components are organized into a tubular system. However, nematodes do not possess Fallopian tubes, which are specialized structures found specifically in the reproductive systems of mammals.

205. (B) Endocrine signaling pathways, including nuclear hormone receptors
The physiology of nematode moulting is a highly coordinated process primarily regulated by internal endocrine signaling pathways. These pathways involve nuclear hormone receptors that respond to specific developmental and environmental cues. These signals trigger the transcription of genes required for the synthesis of the new cuticle and the degradation of the old one, ensuring successful transition between life stages.

206. (C) Four
A typical nematode undergoes exactly four moults during its life cycle. These moults separate five distinct stages: the first stage juvenile (L1) through the fourth stage juvenile (L4), and finally the adult stage. This pattern of four moults is highly conserved across the phylum, providing a structured developmental sequence that allows for growth and maturation within a restrictive exoskeleton.

NODIA

expressing double-stranded RNA revolutionized genetic research. This technique allows for high-throughput, whole-genome reverse genetics screens, where researchers can quickly and easily silence any gene in the nematode. This powerful tool has been used to identify the functions of thousands of previously uncharacterized nematode genes.

262. (C) Free-living, soil-dwelling bacterivore
Ecologically, C. elegans is a free-living, soil-dwelling nematode that functions as a bacterivore. In its natural environment, it feeds on various bacteria found in decaying organic matter. It is not a parasite and can be easily cultured in the laboratory on agar plates seeded with E. coli, which has contributed to its widespread use as a model organism in biology.

263. (A) Three-year lifespan
C. elegans possesses many traits that make it an ideal model organism, including its small body size, a small and completely sequenced genome, and hermaphroditic reproduction. However, it does not have a three-year lifespan; instead, it has a very short life cycle of about three days and a total adult lifespan of only two to three weeks under standard laboratory conditions.

264. (D) Adaptive immunity with antibodies
Research using C. elegans has fundamentally illuminated our understanding of universal biological processes such as aging, longevity, sleep, circadian rhythms, and programmed cell death. However, it has not been a model for the study of adaptive immunity involving antibodies. Nematodes lack an adaptive immune system and instead rely on innate immune responses to protect themselves from pathogens in their environment.

265. (B) Subventral and dorsal esophageal glands
In plant-parasitic nematodes, secreted effector proteins, often referred to as parasitism genes, primarily originate within the three large esophageal glands. These glands consist of one dorsal and two subventral cells. These cells are highly specialized for the rapid synthesis and regulated secretion of proteins that the nematode uses to manipulate host tissues and establish a successful parasitic relationship with host.

266. (C) Injected directly through the hollow oral stylet
Effector proteins are delivered into host plant cells through the hollow oral stylet of the nematode. As the nematode penetrates the root tissue, it uses its muscular pharynx to actively inject these secretions directly into the plant cytoplasm or the surrounding apoplastic space. This direct delivery mechanism allows the nematode to precisely manipulate host cellular processes and suppress host immune responses.

267. (D) They manipulate host expression and signaling to establish feeding sites.
The function of nematode effector proteins extends far beyond simple tissue digestion. While some degrade the cell wall, many others are designed to manipulate host gene expression and signaling pathways. By doing so, these effectors suppress the plant's immune system and induce the profound cellular changes necessary to establish and maintain the specialized feeding sites required for the nematode's successful development.

268. (B) They are all present in non-parasitic nematodes.
Many parasitism genes in nematodes are believed to have been acquired through horizontal gene transfer from soil bacteria or fungi. These genes are specifically associated with the parasitic lifestyle and are generally absent in non-parasitic species. Their expression is tightly regulated, with different esophageal glands producing specific effectors at precise times during the infection and establishment of the feeding site.

269. (B) Subventral glands - Mostly active during early penetration and migration
The subventral and dorsal esophageal glands have distinct roles during the infection process. The subventral glands are primarily active during the early stages of penetration and migration through the root tissue, secreting various cell-wall-degrading enzymes. The dorsal gland becomes more prominent during the establishment and maintenance of the specialized feeding site, secreting effectors that manipulate host cell development and signaling.

270. (B) Penetrate the root but fail to establish or maintain a specialized feeding site
If a critical dorsal gland effector gene is silenced using RNA interference, the nematode's ability

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2011

17. Which statement INCORRECTLY characterizes flooding as a cultural management method?
(A) Flooding creates anaerobic soil conditions that suffocate nematodes.
(B) Flooding for 2 to 3 days is generally sufficient to eradicate root-knot nematodes.
(C) Toxic compounds like hydrogen sulfide are produced during prolonged flooding.
(D) It is an effective traditional practice for nematode control in paddy fields.

2007

18. How does prolonged soil drying (desiccation) negatively impact nematode populations?
(A) It induces immediate egg hatching, starving the juveniles.
(B) It increases the pH of the soil to toxic levels.
(C) It promotes the growth of obligate aquatic nematode predators.
(D) It physically removes the water film required for nematode respiration and movement.

2016

19. What is the primary cause-and-effect relationship in fallowing for nematode management?
(A) Removing host plants forces obligate plant-parasitic nematodes into starvation and population decline.
(B) Leaving soil bare increases soil organic matter, which directly poisons nematodes.
(C) Fallowing increases root exudates in the soil, confusing host-finding behaviors.
(D) Bare soil retains more moisture, encouraging fungal diseases of nematodes.

2006

20. Consider the following statements regarding cultural methods:
I. Fallowing is economically viable for all small-holder farmers.
II. Deep summer ploughing is most effective in arid and semi-arid regions.
III. Weed control is unnecessary during fallowing as weeds do not host nematodes.
IV. Flooding requires a continuous sub-surface hardpan to maintain standing water.
Which of the above statements are incorrect?
(A) I, II and IV
(B) I and III
(C) II, III and IV
(D) II and IV

NODIA

2006

21. How are crops typically classified in a crop rotation scheme designed to manage Meloidogyne incognita?
(A) Classification based on susceptibility into highly susceptible, tolerant, and non-host crops.
(B) Evaluation based on their current cash value in the localized agricultural market.
(C) Determination by their seasonal water requirements, focusing on drought-resistant varieties.
(D) Assessment by their morphological traits, specifically leaf shape and canopy size.

2007

22. When comparing trap crops to antagonistic plants, which of the following is true?
(A) Trap crops kill nematodes through toxic exudates, while antagonistic plants are highly susceptible hosts.
(B) Both trap crops and antagonistic plants support the full reproductive cycle of the targeted nematode.
(C) Antagonistic plants must be uprooted, whereas trap crops are usually harvested for high yield.
(D) Trap crops are destroyed before reproduction, while antagonistic plants actively repel or kill pests.

2009

23. Which of the following is an exception to the general rule that non-hosts reduce nematode populations?
(A) When the non-host crop is grown for a full season without interruption.
(B) When the non-host crop is heavily infested with susceptible weed species.
(C) When the non-host produces nematotoxic root exudates.
(D) When the nematode population consists solely of obligate parasites of the previous crop.

2004

24. What is the primary active nematicidal compound released by the roots of Tagetes species (marigold)?
(A) Glucosinolates
(B) Azadirachtin
(C) Alpha-terthienyl
(D) Hydrogen cyanide

without subsequent nuclear or cellular division. This leads to an increase in the total DNA content of the giant cell nuclei. This genomic expansion is believed to enhance the metabolic capacity and protein synthesis potential of the cell to support the nematode.

280. (D) They are formed by cell wall dissolution between adjacent cells.
Giant cells are specialized feeding structures induced by root-knot nematodes, typically located within the vascular cylinder of the root. Usually, 5 to 7 of these cells are formed per nematode to serve as metabolic sinks. Contrary to syncytia, giant cells are formed by repeated nuclear division without cell division, rather than by the dissolution of cell walls between adjacent host cells.

281. (B) Cytokinesis - Completely absent or bypassed during formation
In the development of giant cells, the host cell cycle is modified so that cytokinesis is completely absent or bypassed after each nuclear division. This leads to the characteristic multinucleate state. While karyokinesis continues, the cell remains a single large unit. This cytological modification is essential for transforming normal root cells into the highly specialized nutrient sinks required by the parasite.

282. (C) Failure of the cells to undergo karyokinesis and endoreduplication, starving the nematode
Giant cell formation is entirely dependent on the nematode's ability to manipulate the host's cell cycle machinery. If the activity of cyclin-dependent kinases is inhibited, the host cells will be unable to undergo the repeated rounds of karyokinesis and endoreduplication required for giant cell development. This results in the failure of the feeding site, causing the nematode to eventually starve.

283. (D) Increased plasma membrane surface area for active transport
Mature giant cells develop extensive cell wall ingrowths, particularly at the interface with the surrounding vascular tissue. These structural adaptations significantly increase the surface area of the plasma membrane. This enhanced surface area facilitates the active transport of water and nutrients from the host's xylem and phloem into the giant cell, ensuring a high-capacity nutritional supply for the developing nematode.

284. (A) Specialized metabolic sinks supplying continuous nutrition
Functionally, giant cells are classified as specialized metabolic sinks. They actively reroute and sequester photoassimilates and other nutrients from the plant's vascular system. By creating this high-demand nutritional hub, the nematode ensures a continuous and abundant supply of the energy and building blocks it needs to complete its life cycle and produce a large number of offspring within host root.

285. (B) Large central vacuole displacing all cytoplasm
Active giant cells are characterized by a dense, metabolic cytoplasm, multiple enlarged and polyploid nuclei, and a high concentration of organelles. Unlike mature, non-parasitized plant cells, they do not possess a large central vacuole that displaces the cytoplasm. Instead, the vacuole is fragmented into many smaller ones to accommodate the high density of cytoplasm and organelles required for nutrient transport.

286. (B) Cytokinin signaling
The induction and development of giant cells involve the complex manipulation of host plant hormones. Cytokinin signaling is particularly important in this process, as it is a key regulator of the cell cycle and division. By altering cytokinin levels or sensitivity, the nematode can trigger the repeated rounds of nuclear division and metabolic activation that are necessary to form these unique structures.

287. (A) Obligate; the sedentary female absolutely depends on the continuous viability of these cells.
The sedentary female root-knot nematode is obligately dependent on the continuous viability and function of its giant cells. Because she is immobile and has a high nutritional demand for egg production, any failure or senescence of the feeding site will directly result in her starvation and death. The successful completion of the nematode's life cycle is inextricably linked to these cells.

288. (A) I, II, III, IV
The development of giant cells follows a specific sequence of events. First, the nematode induces the host cell to begin nuclear division. This is followed by the failure of cytokinesis, leading to

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to manipulate the host will be severely impaired. While the nematode may still be able to penetrate the root, it will fail to establish or maintain the specialized feeding site, such as a syncytium or giant cells. Without this nutritional sink, the nematode will eventually starve.

271. (A) Overcome cell wall barriers and become plant parasites.
The acquisition of enzymes like cellulases and pectate lyases via horizontal gene transfer was a pivotal event in nematode evolution. These genes allowed ancestral nematodes to overcome the formidable structural barriers of the plant cell wall. This biochemical capability enabled them to transition from free-living bacterivores to plant parasites, facilitating the colonization of a vast new ecological niche and host range.

272. (C) Apoplastic (outside the host membrane) and symplastic/cytoplasmic (inside the host cell)
During the initiation and maintenance of feeding sites, nematode effectors are delivered to two primary locations within the host plant tissue. Some are secreted into the apoplastic space, outside the host cell membrane, where they help degrade structural components. Others are injected directly into the host cytoplasm, where they interact with the host cell machinery to manipulate signaling and development.

273. (D) Synthesizing host chloroplasts de novo
Nematode effectors perform a wide variety of functions to ensure successful parasitism, including mimicking plant hormones like auxin, suppressing host immune responses, and modifying the cell cytoskeleton. However, they do not have the capability to synthesize host chloroplasts de novo. Chloroplasts are complex organelles with their own genome, and their development is governed entirely by the plant's own genetic program.

274. (C) Phasmids
The secretion system for nematode effectors is a highly organized process involving the endoplasmic reticulum and Golgi apparatus for protein synthesis and packaging. These proteins are stored in regulated secretory granules and are ultimately expelled through the oral stylet. However, phasmids are posterior sensory organs and are not part of the secretory system used to deliver effectors into host tissue.

275. (B) It becomes enlarged to continuously secrete feeding site effectors.
In sedentary endoparasitic nematodes, the dorsal esophageal gland plays a vital role in the parasitic relationship. This gland becomes significantly enlarged and serves as the primary source of the effectors needed to induce and maintain the specialized feeding sites, such as giant cells or syncytia. The continuous secretion of these proteins is essential for the long-term nutritional success of the sedentary female.

276. (D) Effector repertoires are highly diverse and determine host range and parasitism strategy.
The repertoire of effector proteins is highly diverse across different nematode species. This diversity is a major determinant of a nematode's host range and its specific parasitism strategy. Different species have evolved specialized sets of effectors that allow them to overcome the unique defenses of their preferred hosts and induce the specific types of feeding sites necessary for their life cycle.

NODIA

277. (A) Synchronous karyokinesis (nuclear division) without cytokinesis (cell division)
Root-knot nematodes induce the formation of specialized feeding sites known as giant cells through a unique cytological mechanism. This process involves multiple rounds of synchronous karyokinesis that occur without cytokinesis. As a result, the initial host cells develop into massive, multinucleate structures that are highly specialized for supplying nutrients to the sedentary female nematode.

278. (C) Multinucleate and highly metabolically active
Giant cells induced by root-knot nematodes are characterized by several distinct physiological features. They become multinucleate and highly metabolically active structures. Their cytoplasm is dense and granular, filled with organelles like mitochondria, ribosomes, and plastids. This high level of cellular activity is necessary to support the continuous production of the nutrients required by the nematode for development and egg production.

279. (A) It involves DNA replication without nuclear division.
Endoreduplication is a key process in the development of giant cells. It involves multiple rounds of DNA replication within the nuclei

functioning as essential nutritional sinks for the nematode. However, they differ fundamentally in their mechanism of achieving the multinucleate state. Giant cells arise from nuclear division without cytokinesis, while syncytia are formed by the fusion of many separate cells through wall dissolution.

298. (C) Complete suberization of the entire internal membrane
Functional syncytia possess many structural adaptations, including numerous enlarged nuclei, dissolved internal cell walls that allow for protoplast fusion, and extensive wall ingrowths that increase surface area for nutrient uptake. However, they do not exhibit complete suberization of their internal membranes. Suberization is a process that creates a waterproof barrier, which would hinder the active transport of nutrients from the host.

299. (D) It senesces and dies shortly after the female nematode completes feeding and dies.
The ultimate fate of a syncytium is senescence and death. Once the female nematode completes her feeding and dies, or is removed, the syncytium quickly loses its metabolic activity. The specialized structure, which was maintained by continuous manipulation by the nematode, begins to break down. This local tissue eventually dies, illustrating the obligate and active nature of the parasitic relationship.

300. (A) To reroute photoassimilates to satisfy parasite nutritional demand.
The primary physiological goal for a plant-parasitic nematode in establishing a specialized feeding site is to reroute the plant's photoassimilates to satisfy its own nutritional demands. By creating a powerful metabolic sink, the nematode ensures that sugars and amino acids produced by the plant are diverted away from normal growth and development and instead delivered directly to the parasite.

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metals from the soil.
(B) Nematodes require time to migrate toward the green manure roots.
(C) Immediate planting would expose seedlings to phytotoxic decomposition products and heat.
(D) The soil needs to harden completely before seeds can germinate.

2008

33. What defines a nematophagous fungus as "nematode-trapping"?
(A) It parasitizes nematode eggs using specialized structures.
(B) It captures motile nematodes using rings or nets.
(C) It secretes systemic toxins that paralyze from a distance.
(D) It lives inside the gut, eventually consuming the host.

2022

34. Which biological control agent is an endoparasitic fungus of nematodes?
(A) Pseudomonas fluorescens
(B) Arthrobotrys oligospora
(C) Pochonia chlamydosporia
(D) Drechmeria coniospora

2010

35. Purpureocillium lilacinum (formerly Paecilomyces lilacinus) is primarily known for:
(A) Parasitizing the eggs and sedentary females of root-knot and cyst nematodes.
(B) Capturing adult nematodes with adhesive knobs.
(C) Being an obligate bacterial parasite of nematode juveniles.
(D) Producing volatile fatty acids that fumigate the soil.

2006

36. Which of the following is a correct statement regarding Pochonia chlamydosporia?
(A) It is a predacious nematode that feeds on other nematodes.
(B) It exclusively targets foliar nematodes like Aphelenchoides.
(C) It utilizes chlamydospores for long-term survival in the soil and infects nematode eggs.
(D) It forms constricting rings upon detection of nematode movement.

2002

37. Which statement INCORRECTLY describes the mechanism of Arthrobotrys species?
(A) They rely entirely on zoospores to swim and locate nematode hosts.
(B) They are predacious fungi that develop trapping organs.
(C) Trap formation is often stimulated by the presence of nematodes or their exudates.
(D) Once captured, the fungus penetrates the nematode cuticle and digests its contents.

2023

38. How does the application of Pasteuria penetrans manage nematode populations?
(A) Trapping adults in the soil matrix before they can reach the host root surface.
(B) Producing antibiotics in the rhizosphere to repel infective second-stage juveniles.
(C) Competing with nematodes for specific chemical binding sites on the root surface.
(D) Attaching endospores to juveniles which germinate and sterilize the developing female.

NODIA

2009

39. What is the cause-and-effect relationship when antagonistic rhizobacteria (Pseudomonas spp.) are applied to seeds?
(A) They physically devour nematode eggs present in the soil.
(B) They alter root exudates and produce metabolites to reduce root penetration.
(C) They permanently alter the plant's genome, causing it to produce nematode-specific toxins.
(D) They increase soil pH to 9.0, causing immediate nematode mortality.

2016

40. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Pasteuria penetrans is considered a highly specific obligate parasite of nematodes.
Reason (R): Pasteuria penetrans can be easily mass-cultured on standard artificial media like Potato Dextrose Agar.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

(A) Thick, opaque black films (100-150 μm)
(B) Translucent woven agricultural fabrics (75-100 μm)
(C) Thin, transparent polyethylene films (25-50 μm)
(D) Reflective aluminized mylar sheets (10-20 μm)

2010

9. Comparing soil solarization to chemical fumigation, which of the following is a specific advantage of solarization?
(A) It has a higher efficacy in deep subsoil layers (> 50 cm).
(B) It causes a 'biological vacuum' that eliminates all beneficial soil microbes.
(C) It can be effectively performed during cool, cloudy monsoon seasons.
(D) It frequently induces a positive growth response by increasing soluble nutrients.

2019

10. Consider the following statements regarding soil solarization principles:
I. Transparent plastic is preferred over black plastic because it traps short-wave radiation.
II. Soil moisture must be low (dry soil) to maximize heat conduction.
III. It is most effective in the top 10-15 cm of the soil profile.
Which of the above statement(s) is/are correct?
(A) I and III
(B) I only
(C) II and III
(D) I and II

2023

11. Which factor is most relevant for ensuring the success of soil solarization against root-knot nematodes?
(A) Ensuring the soil is entirely dry before laying the plastic film.
(B) Providing adequate soil moisture before tarping to sensitize nematodes to heat.
(C) Using the thickest available black plastic to block weed growth.
(D) Limiting the solarization period to a maximum of 5 days.

2021

12. From the physical parameters of hot water treatment, what can be inferred about its application to planting material?
(A) It provides permanent systemic protection to the growing plant.
(B) The temperature and duration must be strictly controlled to prevent phytotoxicity.
(C) It is highly specific to nematodes and cannot kill fungal pathogens.
(D) It is only effective against ectoparasitic nematodes on the root surface.

2017

13. Which definition best describes phytosanitation in the context of nematode management?
(A) Using clean, certified material and hygienic practices to prevent pest introduction.
(B) The complete eradication of nematodes from an entire geographical region.
(C) The application of botanical extracts to manage existing nematode populations.
(D) The breeding of plant varieties with inherent genetic resistance.

2015

14. What are the standard hot water treatment parameters for controlling Ditylenchus dipsaci in narcissus bulbs?
(A) 35.5 °C for 10 minutes
(B) 44.5 °C for 3 to 4 hours
(C) 60.0 °C for 30 minutes
(D) 80.0 °C for 5 minutes

2003

15. Which of the following is a factual statement regarding hot water treatment of banana suckers for Radopholus similis?
(A) Peeling the corm before treatment decreases the efficacy of the heat penetration.
(B) Suckers should be immersed in boiling water (100 °C) for exactly 1 minute.
(C) It effectively immunizes the banana plant against future infections in the field.
(D) Treatment is typically done at 55 °C for 20 minutes.

2006

16. Which of the following is a correct statement about cultural management via deep summer ploughing?
(A) It increases nematode survival by burying them below the frost line.
(B) It aims to expose deep-dwelling nematode life stages to solar desiccation and predators.
(C) It requires the application of nitrogenous fertilizers simultaneously to be effective.
(D) It is exclusively effective against cyst nematodes and has no effect on root-knot nematodes.

NODIA

CHAPTER 07
Nematode Management

2006

1. What is the fundamental principle defining the Economic Threshold Level (ETL) in nematode management?
(A) The density where the value of yield loss equals the cost of pesticide application.
(B) The density where management must be initiated to prevent reaching the Injury Level.
(C) The population density a crop can sustain without showing any detectable symptoms.
(D) The absolute pest density where total failure occurs regardless of chemical treatment.

2019

2. Which sampling pattern is generally considered most statistically reliable for estimating unevenly distributed phytoparasitic nematode populations in a field?
(A) Straight diagonal transect across the plot.
(B) Sampling conducted only along field margins.
(C) Single central deep core sampling method.
(D) Stratified zigzag or 'W' sampling pattern.

2018

3. In the context of economic injury levels (EIL), which mathematical parameter directly represents the loss in yield per nematode?
(A) The damage coefficient
(B) The economic threshold threshold multiplier
(C) The cost-benefit ratio
(D) The multiplication rate

2024

4. Which of the following statements correctly differentiates ETL from EIL?
(A) ETL is determined post-harvest, whereas EIL is measured pre-planting.
(B) ETL fluctuates with market value, but EIL remains constant regardless of economics.
(C) ETL is always a numerically lower population density than EIL.
(D) ETL applies only to endoparasites, while EIL is specific to ectoparasites.

2013

5. Which statement regarding nematode population sampling for management decisions is INCORRECT?
(A) A single five-kilogram composite sample from ten hectares provides minimal variance.
(B) Sampling depth should match the active root zone of the intended crop.
(C) Moist soil samples must be protected from direct sunlight and overheating during transit.
(D) Sub-sampling for extraction is usually performed after thoroughly mixing the composite sample.

2013

6. If a high-value cash crop is planted in a field with a moderate root-knot nematode population, how does this affect the ETL compared to a low-value crop?
(A) The ETL is raised because the crop's higher vigor compensates for more nematode damage.
(B) The ETL remains consistent because biological damage thresholds are independent of price.
(C) The ETL becomes invalid because high-value crops are always treated regardless of density.
(D) The ETL is lowered because the crop's financial value justifies an earlier intervention.

2002

7. What is the primary physical cause of nematode mortality during soil solarization?
(A) Accumulation of toxic levels of carbon dioxide under the tarp.
(B) Denaturation of cellular proteins and enzymes due to high soil heat.
(C) Anaerobic conditions generated by the complete block of oxygen exchange.
(D) Ultraviolet radiation penetrating the soil profile to a depth of 30 cm.

2017

8. How are poly-films typically classified for optimal soil solarization efficacy?

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2007

25. Which definition accurately defines a "catch crop" in nematode management?
(A) A high-value crop that yields economic returns while simultaneously breeding soil-borne nematodes.
(B) A non-host crop that physically traps migrating infective juveniles within its fibrous root hairs.
(C) A perennial crop that effectively masks the chemical signals of nearby susceptible host species.
(D) A susceptible crop used to stimulate infection and then destroyed before nematode reproduction.

2025

26. Which of the following is the primary mechanism by which oil cakes suppress soil-borne nematodes?
(A) Decomposition products like ammonia and volatile fatty acids released by microbial activity.
(B) Physical alteration of the soil texture effectively preventing nematode locomotion.
(C) Direct inhibition of nematode acetylcholinesterase by the application of intact oil cake.
(D) Creation of a sterile soil environment that is entirely devoid of all soil microorganisms.

2021

27. Which of the following is a factual outcome of incorporating green manure (like Crotalaria juncea) into nematode-infested soil?
(A) It significantly reduces the population of free-living, beneficial nematodes.
(B) It encourages the proliferation of nematophagous fungi and releases toxic decomposition products.
(C) It lowers the soil temperature drastically, freezing the nematode eggs.
(D) It provides a permanent, impenetrable physical barrier around susceptible plant roots.

2002

28. Which is the correct statement concerning the release of ammonia from organic soil amendments?
(A) Ammonia is primarily released under strictly aerobic conditions from pure carbohydrate amendments.
(B) High levels of ammonia released during the decomposition of nitrogen-rich amendments are highly toxic to nematodes.
(C) Ammonia promotes rapid nematode egg hatching and increases their lifespan.
(D) The nematicidal effect of ammonia is most pronounced in highly acidic soils ($pH < 4$).

2009

29. Which statement regarding the role of phenolics in organic amendments is INCORRECT?
(A) Phenolics are the sole compounds responsible for the efficacy of neem cake.
(B) Phenolic compounds are released during the breakdown of certain organic matter.
(C) They can disrupt nematode cuticle integrity and internal physiology.
(D) They often exhibit broad-spectrum antimicrobial and nematicidal properties.

2018

30. Consider the following statements regarding organic amendments:
I. Neem cake contains azadirachtin and other limonoids that suppress nematodes.
II. Organic amendments generally decrease soil water holding capacity.
III. Volatile fatty acids like acetic and butyric acid are byproducts of organic matter decomposition.
IV. Amendments require a decomposition period to become fully nematicidal.
V. Karanj cake is entirely ineffective against root-knot nematodes.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and V
(D) I, IV and V

NODIA

2009

31. Which of the following is considered the most relevant factor determining the success of organic amendments in the field?
(A) The specific geometric shape of the organic particles.
(B) The specific phase of the moon during amendment.
(C) The use of systemic fungicides applied at the same time.
(D) The C:N ratio and the prevailing soil environment.

2001

32. What can be inferred from the requirement of a waiting period after applying green manure before planting?
(A) The green manure must absorb all heavy

a multinucleate state. The nuclei then undergo endoreduplication to increase DNA content. Finally, the cell develops extensive wall ingrowths to maximize nutrient transport from the plant's vascular system.

289. (D) Dissolution of cell walls and protoplast fusion of adjacent cells
Cyst nematodes induce the formation of a feeding site known as a syncytium. Unlike the giant cells of root-knot nematodes, a syncytium is formed by the localized dissolution of cell walls between adjacent host cells. This process leads to the fusion of many individual protoplasts into a single, continuous, multinucleate cellular mass that serves the nutritional needs of the parasite.

290. (C) Incorporating neighboring cells through partial wall degradation
A syncytium expands by progressively incorporating hundreds of neighboring root cells. This is achieved through the targeted degradation of cell walls at specific locations, primarily near the initial feeding cell. As the cell walls are removed, the protoplasts of the adjacent cells fuse with the expanding syncytium, creating a massive, interconnected metabolic sink that draws nutrients from the surrounding tissue.

291. (B) Targeted enzymatic degradation occurs at specific pit fields.
The dissolution of cell walls during syncytium formation is a highly controlled enzymatic process. The nematode secretes specific effectors that trigger the host's own cell-wall-modifying enzymes, such as endoglucanases and expansins. This targeted degradation occurs primarily at pit fields, where the cell wall is already thinner. This allows for the orderly fusion of adjacent cells into the multinucleate feeding structure.

292. (D) The nuclei within a syncytium undergo synchronous mitosis without cytokinesis.
Syncytia are multinucleate structures that function as highly active metabolic sinks and feature extensive cell wall ingrowths. However, unlike giant cells, the multinucleate state is achieved through the fusion of many individual cells after cell wall dissolution, rather than through repeated rounds of synchronous mitosis within a single cell. The nuclei within the syncytium do not typically undergo synchronous divisions.

293. (A) Syncytia - Formed by protoplast fusion
The primary difference between these two feeding sites lies in their mode of formation. Syncytia are formed by the protoplast fusion of many adjacent host cells following enzymatic cell wall degradation. In contrast, giant cells are formed by the repeated nuclear division of a few initial cells without subsequent cytokinesis. Both structures serve as specialized nutrient sources but arise through different pathways.

294. (C) Arrested syncytium expansion and subsequent nematode death/starvation
If a host plant lacks the specific enzymes necessary for localized cell wall degradation, the cyst nematode will be unable to expand its syncytium. The initial feeding cell will fail to incorporate neighboring cells, resulting in a significantly undersized and inadequate nutritional sink. This arrested development will prevent the nematode from acquiring enough nutrients to complete its life cycle, leading to eventual starvation.

295. (A) Access a massive, continuously expanding nutrient pool.
The progressive incorporation of hundreds of host cells into a single syncytium provides the cyst nematode with a massive and continuously expanding nutrient pool. This large cellular continuum is directly connected to the plant's vascular system, allowing the nematode to access an abundant supply of photoassimilates. This high-capacity nutritional sink is essential for the growth and reproduction of the female.

296. (D) Multinucleate fused cellular continuum (symplast)
A mature syncytium is classified as a multinucleate, fused cellular continuum, or symplast. It represents a large volume of host tissue that has been physiologically and structurally transformed into a single functional unit. This structure is highly specialized for the active transport and sequestration of nutrients, effectively acting as an artificial sink that dominates the local root metabolism for the nematode's benefit.

297. (B) Mechanism of achieving the multinucleate state
Giant cells and syncytia share several common features, including being multinucleate, having a dense and metabolically active cytoplasm, and

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2023

41. How are antagonistic bacteria such as Bacillus firmus generally classified in commercial formulations?
(A) As chemical soil fumigants
(B) As botanical extracts
(C) As synthetic growth regulators
(D) As bionematicides

2002

42. Comparing Purpureocillium lilacinum to Arthrobotrys oligospora, which specific stage of the root-knot nematode life cycle does each primarily target?
(A) P. lilacinum targets eggs, while A. oligospora targets motile juveniles.
(B) Both primarily target motile second-stage juveniles (J2).
(C) P. lilacinum targets adult males, while A. oligospora targets eggs.
(D) Both primarily target the gelatinous egg mass matrix only.

2004

43. Which characteristic is most relevant in identifying Mononchid nematodes as predators?
(A) The presence of a delicate, hollow stylet for piercing plant cells.
(B) A heavily sclerotized, barrel-shaped buccal cavity often armed with a large mural tooth.
(C) The presence of constricting rings around their tail region.
(D) A highly degenerate digestive tract, relying on symbiotic bacteria.

2004

44. Based on their feeding biology, what can be inferred about the widespread commercial use of predatory Mononchids in field agriculture?
(A) They are easy to mass-produce in vitro and are widely sold as biopesticides.
(B) Their cannibalistic nature and sensitivity to environmental changes make commercial field application difficult.
(C) They are highly host-specific, only eating root-knot nematodes and ignoring all others.
(D) They completely replace the need for crop rotation.

2012

45. What defines the role of antagonistic soil micro-arthropods (e.g., Collembola, certain mites) in nematode ecology?
(A) They are generalist predators that consume nematodes along with fungi and organic debris.
(B) They act as obligate intermediate hosts for phytoparasitic nematodes.
(C) They secrete volatile fumigants that kill nematodes in soil pores.
(D) They physically transport nematode eggs into the plant vascular system.

2024

46. Which of the following identifies a known group of predatory nematodes?
(A) Heteroderids
(B) Tylenchulids
(C) Diplogasterids
(D) Hoplolaimids

2017

47. In which year was the Plant Quarantine (Regulation of Import into India) Order (PQO) primarily updated to align with the WTO-SPS agreement?
(A) 1985
(B) 1990
(C) 2003
(D) 2015

2011

48. Which of the following is a factual statement regarding Pest Risk Analysis (PRA) in plant quarantine?
(A) PRA is conducted only after a new pest has fully established itself in a country.
(B) PRA guarantees that no biological control agents can ever be imported.
(C) PRA assesses the probability of pest introduction and its potential economic impact to justify quarantine measures.
(D) PRA is exclusively concerned with pests of human health, not agricultural pests.

2024

49. Which statement about international phytosanitary certification is INCORRECT?
(A) It is issued by the National Plant Protection Organization (NPPO) of the exporting country.
(B) It eliminates the need for any physical inspection at the port of entry.
(C) It certifies that plants or plant products meet the specific phytosanitary import requirements of the importing country.
(D) It is governed by standards established under the International Plant Protection Convention (IPPC).

NODIA

(A) To prevent the chemical from washing down into the groundwater.
(B) To create a dark environment, as the chemical degrades instantly in darkness.
(C) To increase the soil temperature to boiling point.
(D) To trap the toxic gas in the soil profile long enough to achieve a lethal concentration-time (CT) product.

2006

67. Which of the following is considered an exception to the rule that fumigants are generally phytotoxic?
(A) DBCP, which could historically be used on living fruit tree roots.
(B) Metam sodium applied directly over a growing lettuce crop.
(C) Methyl bromide applied to established vineyards.
(D) 1,3-Dichloropropene applied at seed planting time.

2007

68. What defines the biochemical mode of action of carbamate nematicides?
(A) They inhibit chitin synthase during eggshell formation.
(B) They uncouple oxidative phosphorylation in the mitochondria.
(C) They bind to and reversibly inhibit the enzyme acetylcholinesterase at neuronal synapses.
(D) They destroy the lipid bilayer of the nematode's sensory amphids.

2001

69. Which non-fumigant nematicide is an organophosphate?
(A) Fenamiphos
(B) Carbofuran
(C) Aldicarb
(D) Oxamyl

2006

70. Non-fumigant nematicides like Carbofuran are often referred to as "nematistats" rather than strict nematicides at field doses because:
(A) They only kill stationary adult stages.
(B) They work by statistically reducing the egg count without affecting juveniles.
(C) They are purely repellent and do not enter the nematode body.
(D) They paralyze pests to prevent root feeding.

2002

71. Which of the following is a correct statement regarding the application of systemic non-fumigant nematicides?
(A) They evaporate completely within 10 minutes of soil application.
(B) They are readily absorbed by plant roots and translocated acropetally (upward) in the xylem to protect against foliar and root-feeding nematodes.
(C) They must be applied directly to the leaves to control root-knot nematodes.
(D) They are totally insoluble in water, requiring heavy oil solvents for application.

2005

72. Which statement INCORRECTLY characterizes the behavior of organophosphate nematicides?
(A) They interfere with the transmission of nerve impulses in nematodes.
(B) Highly toxic to mammals due to their AChE inhibitory action.
(C) They are highly volatile and primarily move through the soil as a gas.
(D) Over-reliance on them can lead to accelerated microbial degradation in the soil.

2019

73. What is the conceptual consequence if acetylcholinesterase (AChE) is permanently inhibited in a nematode?
(A) The nematode fails to produce acetylcholine, resulting in a flaccid paralysis.
(B) The nematode's stylet completely dissolves.
(C) The cuticle becomes highly permeable, leading to osmotic bursting.
(D) AChE inhibition leads to acetylcholine buildup and lethal tetany.

2001

74. In a cause-and-effect scenario, what happens if an organophosphate is washed out of the root zone by heavy rain shortly after application?
(A) Paralyzed nematodes may recover and resume feeding as the chemical concentration drops below the effective threshold.
(B) Nematodes permanently lose their ability to reproduce.
(C) The chemical undergoes spontaneous conversion into a fumigant.
(D) The plant roots immediately absorb the excess water and die of toxicity.

2012

75. How are next-generation nematicides like Fluopyram biochemically classified?

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(C) A botanical extract that coats the seed and repels juveniles.
(D) A volatile compound that turns into a gas and diffuses through soil pore spaces to kill nematodes.

2015

58. Which historical nematicide was widely used until it was discovered to cause male sterility in factory workers and groundwater contamination?
(A) DBCP (1,2-dibromo-3-chloropropane)
(B) Methyl bromide
(C) 1,3-Dichloropropene
(D) Metam sodium

2004

59. Which of the following is a factual statement regarding the history of DD mixture?
(A) It is currently the most widely used nematicide in organic farming.
(B) It was a mixture of 1,3-dichloropropene and 1,2-dichloropropane.
(C) It was developed in the 21st century as a safer alternative to bio-pesticides.
(D) It acts strictly as a contact nematicide without any volatility.

2003

60. Arrange the following events regarding the global status of Methyl Bromide in the correct chronological order:
I. Widespread use
II. Ozone depletion discovery
III. Montreal Protocol phase-out
(A) I, II, III
(B) III, I, II
(C) II, I, III
(D) I, III, II

2008

61. Which statement correctly describes the action of the Montreal Protocol on nematode management?
(A) It phased out the production and use of methyl bromide due to its ozone-depleting properties.
(B) It mandated the use of methyl bromide for all international grain shipments.
(C) It banned the use of all chemical nematicides globally.
(D) It established the Economic Threshold Levels for all root-knot nematodes.

2010

62. Which of the following statements about early fumigants is INCORRECT?
(A) Many early fumigants were halogenated hydrocarbons.
(B) Methyl bromide had excellent penetrating power and broad-spectrum activity against pests, weeds, and pathogens.
(C) DD mixture was highly specific, killing only nematodes while preserving all soil fungi and bacteria.
(D) DBCP was unique among fumigants because it could be applied to living, established perennial crops without severe phytotoxicity.

2012

63. How does the physical property of vapor pressure affect a soil fumigant's efficacy?
(A) Low vapor pressure allows the chemical to diffuse rapidly through large volumes of soil.
(B) Vapor pressure determines whether the fumigant is absorbed by the plant foliage.
(C) Vapor pressure has no relation to the movement of fumigants in soil.
(D) High vapor pressure is required for the chemical to volatilize and move effectively through soil air spaces.

2002

64. What is the primary cause of Metam sodium's nematicidal activity in the soil?
(A) It remains a stable molecule that nematodes ingest.
(B) It directly inhibits the shedding of the nematode cuticle.
(C) It breaks down in moist soil to generate methyl isothiocyanate (MITC), a highly toxic gas.
(D) It acts as an artificial hormone causing premature egg hatching.

2019

65. How does 1,3-Dichloropropene (1,3-D) differ from organophosphate nematicides?
(A) 1,3-D is a broad-spectrum insecticide, while organophosphates only kill nematodes.
(B) 1,3-D is a fumigant that moves as a gas, whereas organophosphates are non-fumigants moving in soil water.
(C) 1,3-D is applied as a foliar spray, whereas organophosphates must be injected.
(D) 1,3-D acts by inhibiting AChE, whereas organophosphates dissolve the nematode cuticle.

NODIA

2018

66. Why is soil sealing (e.g., with plastic tarp or water seal) essential after applying 1,3-D?

remaining active for several years after a single application.
(D) They are considered safe for non-target mammals and are used in organic farming.

2018

85. What is the conceptual advantage of using seed treatment formulations of nematicides?
(A) It provides localized protection to the emerging radicle while drastically reducing the total amount of active ingredient applied per hectare.
(B) It requires massive volumes of chemical, ensuring deep soil penetration.
(C) It permanently eliminates the need for crop rotation.
(D) It completely sterilizes the entire soil profile.

2014

86. In the context of application technology, what does the abbreviation "EC" stand for?
(A) Effective Chemical
(B) Encapsulated Compound
(C) Economic Control
(D) Emulsifiable Concentrate

2006

87. What is the cause-and-effect relationship in chemigation/nemigation?
(A) Mixing nematicides with water strictly neutralizes their active ingredients.
(B) Applying through irrigation ensures uniform distribution in the root zone.
(C) Chemigation creates a vapor cloud above the crop, killing foliar nematodes exclusively.
(D) Applying chemicals through drip lines specifically clogs the emitters.

2015

88. How are bare-root dip treatments classified in application technology?
(A) Broad-spectrum soil fumigation.
(B) Post-harvest curative application.
(C) Pre-plant localized chemical or biological treatment for transplants/seedlings.
(D) Foliar systemic spraying.

2012

89. Comparing Granular (G/GR) formulations to Emulsifiable Concentrates (EC), which of the following is true?
(A) Granules are highly volatile and act as fumigants in dry soil.
(B) Granules are exclusively used for foliar applications.
(C) ECs are less prone to leaching than Granules.
(D) Granules require soil incorporation while ECs are applied via water.

2025

90. Consider the following statements regarding nematicide application:
I. Seed treatments are effective for protecting deep-rooted perennial crops throughout their lifespan.
II. Bare-root dip relies on the absorption of the nematicide by the roots prior to transplanting.
III. Chemigation is highly compatible with modern drip irrigation systems.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2023

91. Which component is most relevant as a pre-infectional structural barrier in host plant resistance?
(A) Rapid cell death (necrosis)
(B) Thickened root endodermis and highly suberized root epidermal cell walls
(C) Synthesis of phytoalexins
(D) Production of pathogenesis-related (PR) proteins

2016

92. What can be inferred when a plant exhibits a hypersensitive response (HR) upon nematode invasion?
(A) The plant is highly susceptible and provides excessive nutrients to the nematode.
(B) The plant triggers localized, programmed cell death at the site of infection, starving the biotrophic nematode.
(C) The plant ignores the nematode, allowing it to form a giant cell without resistance.
(D) The plant roots immediately die completely, leading to total crop loss.

2013

93. Which definition best describes phytoalexins in the context of post-infectional biochemical defense?
(A) Low molecular weight antimicrobial compounds synthesized de novo by plants in response to infection.
(B) Pre-existing physical barriers on the root surface.
(C) Chemical attractants secreted by roots to

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(A) Acetylcholinesterase inhibitors
(B) Succinate dehydrogenase inhibitors (SDHI) affecting complex II of the mitochondrial respiratory chain
(C) Fumigants generating methyl isothiocyanate
(D) Juvenile hormone analogues

2003

76. Comparing Fluensulfone to traditional organophosphates, what is a primary advantage of Fluensulfone?
(A) It is much cheaper to synthesis than organophosphates.
(B) It has a novel mode of action with a significantly lower toxicity profile to mammals and non-target organisms.
(C) It acts as a powerful soil fumigant.
(D) It is an organic botanical extract.

2009

77. Which feature is most relevant to the action of Spirotetramat against nematodes?
(A) It has two-way systemicity (ambimobile), translocating via both xylem and phloem after foliar application.
(B) It acts strictly as a contact poison in the soil.
(C) It is a highly volatile gas used for grain fumigation.
(D) It works by inhibiting acetylcholinesterase.

2015

78. What can be inferred about the mode of action of Fluensulfone from its behavioral effects on nematodes?
(A) It completely dissolves the eggshells, preventing any hatching.
(B) It causes the nematode to rapidly multiply before dying.
(C) It targets a novel neurological pathway distinct from AChE.
(D) It only affects nematodes if they actively ingest plant sap.

2018

79. Which definition best encapsulates "biorational nematicides"?
(A) Chemicals designed to be as toxic as possible to all existing soil life.
(B) Any chemical compounds that have been banned by the Montreal Protocol.
(C) Fertilizers that incidentally kill nematodes through direct osmotic stress.
(D) Natural or synthetic products with low impact and structural natural parity.

2013

80. Arrange the following chemical control eras or methods from the earliest widespread adoption to the most recent development:
I. Methyl bromide fumigation
II. Discovery of AChE inhibitors (OPs/ Carbamates)
III. Development of SDHI nematicides (Fluopyram)
IV. Banning of DBCP
(A) I, II, IV, III
(B) II, I, III, IV
(C) I, IV, II, III
(D) IV, I, II, III

2004

81. Which botanical compound is the primary nematicidal active ingredient in neem products?
(A) Pyrethrin
(B) Azadirachtin
(C) Rotenone
(D) Nicotine

2017

82. Which of the following is a factual statement regarding Avermectins (such as Abamectin)?
(A) They are produced by the roots of marigold plants.
(B) They are produced by the synthesis of halogenated hydrocarbons in a laboratory.
(C) They are produced by the mechanical crushing of mustard seeds.
(D) They are produced by the fermentation of the soil actinomycete Streptomyces avermitilis.

2013

83. Identify the correct statement regarding the mechanism of Abamectin.
(A) It binds to glutamate-gated chloride channels, increasing chloride ion permeability and causing flaccid paralysis.
(B) It stimulates excessive production of acetylcholinesterase.
(C) It acts as a physical barrier preventing nematodes from entering the root.
(D) It inhibits the enzyme succinate dehydrogenase.

2018

84. Which statement INCORRECTLY describes commercial formulations of Azadirachtin?
(A) They are derived from the seeds of Azadirachta indica.
(B) They act by disrupting nematode molting and reducing egg hatching.
(C) They are highly persistent in the soil,

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were completed.
(C) All nematode genomes are exactly identical in size and gene content.
(D) Meloidogyne incognita has a highly complex, polyploid, and asexual genome.

2021

119. Which of the following is a factual statement regarding targeting nematode effectors through HIGS?
(A) It aims to provide the nematode with extra nutrients.
(B) It aims to disable the nematode's ability to manipulate the host and establish feeding sites.
(C) It aims to make the plant synthesize nematode effectors instead of plant proteins.
(D) It aims to kill the nematode instantly upon contact with the root epidermis.

2003

120. Consider the following statements regarding nematode omics:
I. Transcriptomics studies all the RNA transcripts produced under specific conditions.
II. The parasitome strictly excludes proteins secreted from the subventral esophageal glands.
III. Comparative genomics can help identify targets for broad-spectrum nematicides.
IV. Globodera species secrete effectors to form syncytia, not giant cells.
Which of the following is/are INCORRECT?
(A) I and III
(B) II only
(C) II and IV
(D) I, III and IV

2010

121. Identify the correct statement regarding the application of transcriptomics in identifying novel targets.
(A) Transcriptomics is only useful for identifying completely static genes that never change expression.
(B) Transcriptomics completely replaces the need for field testing of nematicides.
(C) It provides a permanent map of the DNA sequence, but no functional data.
(D) Transcriptomics reveals stage-specific upregulated genes to highlight disruption targets.

2021

122. Which statement INCORRECTLY characterizes the esophageal glands of plant-parasitic nematodes?
(A) The dorsal gland is predominantly active during the invasion and migration phase in the root.
(B) They are the primary source of parasitism proteins (effectors).
(C) They typically consist of one dorsal and two subventral glands.
(D) The contents of the glands are secreted through the stylet into plant tissues.

2022

123. What conceptual breakthrough allowed researchers to specifically profile the transcriptomes of nematode esophageal glands?
(A) The use of standard light microscopy.
(B) The development of microaspiration techniques combined with RNA sequencing (RNA-seq).
(C) Grinding up entire roots and sequencing all bulk DNA.
(D) Visually observing the glands changing color during infection.

2011

124. In cause-and-effect terms, if an RNAi construct successfully targets a major cell wall-degrading enzyme (CWDE) in a root-knot nematode, what is the likely outcome?
(A) The nematode will reproduce exponentially faster.
(B) The nematode's ability to migrate through the root cortex will be significantly impaired.
(C) The plant will immediately die of a systemic hypersensitive response.
(D) The nematode will switch to feeding exclusively on root hairs from the outside.

2015

125. How do Globodera effectors functionally classify in terms of feeding site induction compared to Meloidogyne?
(A) Globodera induces syncytia via cell fusion, while Meloidogyne induces giant cells via mitosis.
(B) Globodera effectors induce giant cells, while Meloidogyne induces syncytia.
(C) Both induce exactly the same feeding structure using identical effectors.
(D) Neither induces feeding structures; both are strictly migratory endoparasites.

NODIA

guide nematodes.
(D) Nematode enzymes used to degrade plant cell walls.

2012

94. Which major resistance gene confers resistance to multiple Meloidogyne species in tomato?
(A) H1 gene
(B) Hs1pro-1 gene
(C) Mi-1.2 gene
(D) Rx gene

2017

95. The H1 gene provides resistance to which nematode in potato?
(A) Meloidogyne incognita
(B) Radopholus similis
(C) Globodera pallida
(D) Globodera rostochiensis

2007

96. Which of the following is a correct statement regarding the expression of the Mi gene in tomato?
(A) It provides absolute immunity to all known genera of plant-parasitic nematodes.
(B) It works by secreting lethal fumigant gases into the rhizosphere.
(C) Its resistance breaks down at soil temperatures above 28°C.
(D) It is a recessive gene requiring homozygous alleles to show any resistance.

2025

97. Which statement INCORRECTLY characterizes the Hs1pro-1 gene?
(A) It was introgressed into sugarbeet from Beta procumbens.
(B) It provides resistance primarily through the production of thick waxy cuticles on leaves.
(C) It confers resistance to the sugarbeet cyst nematode, Heterodera schachtii.
(D) It was the first cloned nematode resistance gene.

2013

98. What is the conceptual framework behind Integrated Nematode Management (INM)?
(A) Relying on a single toxic chemical to achieve 100% eradication.
(B) Using biological agents to manage nematodes strictly organically.
(C) Ignoring the pest until visual symptoms appear, then applying chemicals.
(D) Combining multiple compatible tactics to keep populations below ETL.

2015

99. In INM, what is an example of a synergistic interaction between two management methods?
(A) Using sub-lethal doses of a nematicide that weakens nematodes, making them more susceptible to infection by Pasteuria penetrans.
(B) Applying a broad-spectrum fumigant simultaneously with a biological control fungus, resulting in the death of the fungus.
(C) Planting a susceptible crop continuously while hoping indigenous predators control the pest.
(D) Flooding the field while simultaneously trying to conduct soil solarization.

2018

100. Match the crop and pest scenario in List I with an appropriate INM component in List II.
List I: (Scenario)
P. Root-knot nematode in protected cultivation (polyhouse)
Q. Potato Cyst Nematode in Nilgiris
R. Citrus nematode in established orchards
S. Root-lesion nematode in wheat
List II: (Component)
1. Strict domestic quarantine and resistant varieties (Kufri Swarna)
2. Application of systemic non-fumigants via drip irrigation
3. Soil solarization combined with bio-agents prior to planting
4. Crop rotation with non-hosts like mustard or legumes
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-1, R-4, S-3

2009

101. Which classification correctly differentiates RNA interference (RNAi) from traditional transgenic toxins (like Bt)?
(A) RNAi silences specific mRNA, while Bt produces a protein toxic to the nematode gut.
(B) RNAi relies on physical barriers, while Bt relies on various synthetic chemical toxins.
(C) RNAi introduces bacterial genes, whereas Bt alters the plant's own structural DNA.
(D) RNAi targets eggshells in the soil, whereas Bt targets adult males via root surface.

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2024

50. Match the quarantine or legislative term in List I with its correct description in List II.

List I: (Term)

P. PRA

Q. NPPO

R. PQO 2003

S. IPPC

List II: (Description)

1. Global treaty to prevent the spread of plant pests
2. Evaluates the threat level of a potential imported pest
3. The official service responsible for phytosanitary certification in a country
4. Indian legislation regulating agricultural imports

(A) P-2, Q-3, R-4, S-1

(B) P-1, Q-2, R-3, S-4

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-4, R-1, S-3

2023

51. The domestic quarantine in India regarding the Potato Cyst Nematode (PCN) restricts the movement of potato tubers from which region?

(A) Nilgiri Hills (Tamil Nadu)

(B) Indo-Gangetic Plains

(C) Malwa Plateau

(D) Brahmaputra Valley

2025

52. Why was the domestic quarantine for Potato Cyst Nematode (Globodera spp.) established in India?

(A) To prevent the export of potatoes to European markets.

(B) To force farmers in the Nilgiris to switch from potato to tea cultivation.

(C) To confine the highly destructive nematode to the localized areas of the Nilgiris and prevent spread to other major potato-growing regions.

(D) Because the nematode also attacks the local tea plantations in that region.

2023

53. Which classification correctly categorizes domestic and international quarantines?

(A) Domestic quarantine restricts pest movement within a country, while international quarantine regulates cross-border movement.

(B) Domestic quarantine deals only with insects, while international quarantine deals with nematodes.

(C) Domestic quarantine is a physical barrier, while international quarantine is purely chemical.

(D) Domestic quarantine relies on PRA, whereas international quarantine does not.

2011

54. Comparing domestic quarantine to chemical control, which of the following represents the distinct nature of quarantine?

(A) Quarantine acts curatively after crop damage occurs.

(B) Quarantine provides immediate eradication of the pest from the soil.

(C) Quarantine solely utilizes natural enemies for enforcement.

(D) Quarantine aims at exclusion and containment, whereas chemical control aims at population reduction in an infested field.

2014

55. What is the most relevant biological reason why Potato Cyst Nematodes are strictly quarantined?

(A) They have a very broad host range including all cereal crops.

(B) Their cysts can remain viable in the soil for 10-20 years without a host, making eradication extremely difficult.

(C) They are highly mobile and can migrate kilometers through the soil unassisted.

(D) They cause immediate death of the potato plant upon single juvenile penetration.

2006

56. What can be inferred about the discovery of PCN in regions outside the Nilgiris despite quarantine measures?

(A) The nematode spontaneously mutated from local non-parasitic species.

(B) The quarantine laws explicitly allowed limited transport of infested soil.

(C) Quarantine enforcement may have had breaches, such as the unregulated movement of seed potatoes or soil on farm machinery.

(D) Potato Cyst Nematodes can fly long distances during their adult stage.

2005

57. Which chemical definition best describes a true soil fumigant used in nematode management?

(A) A chemical that is strictly systemic and moves downward through the phloem to the roots.

(B) A solid granular material that strictly poisons nematodes upon ingestion.

NODIA

II. HIGS allows the plant to act as a delivery system for the dsRNA.
III. DICER enzymes in the nematode cleave the ingested dsRNA into siRNAs.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2016

111. What is the cause-and-effect relationship in whole-genome sequencing of phytoparasitic nematodes?
(A) Sequencing directly kills the nematodes in the soil.
(B) Whole-genome sequencing causes the nematodes to mutate into non-parasitic forms.
(C) Identifying the genome automatically creates a transgenic plant without further laboratory work.
(D) Generating a high-quality genome identifies molecular targets for resistance.

2012

112. How has the model organism Caenorhabditis elegans helped plant nematology?
(A) It is the most destructive plant parasite, so studying it directly solves agricultural problems.
(B) It is a predator of plant-parasitic nematodes and is used extensively in field biocontrol.
(C) As a sequenced model, it serves as a baseline for comparative and functional genomics.
(D) It produces unique antibiotics that are currently commercialized as nematicides.

2005

113. Which classification best describes the term "parasitome" in nematode transcriptomics?
(A) The complete set of genes a nematode uses exclusively for digesting soil bacteria.
(B) The collection of secreted proteins and effectors produced in the esophageal glands.
(C) The physical organs used by nematodes to sense temperature.
(D) The group of endosymbiotic bacteria living within the nematode.

2025

114. Comparing Meloidogyne genomes to C. elegans, what notable expansion is found in root-knot nematodes due to their parasitic lifestyle?
(A) Genes for visual photoreception.
(B) Genes for synthesizing their own sunlight-based chlorophyll.
(C) A massive reduction in all metabolic genes requiring them to absorb whole proteins from the plant.
(D) Genes encoding plant cell wall-degrading enzymes acquired via horizontal transfer.

2015

115. Which feature is most relevant when analyzing the transcriptomic profile of nematode esophageal glands?
(A) Identifying effectors injected into host cells to induce specialized feeding structures.
(B) Identifying proteins responsible for forming the structural cuticle.
(C) Determining the genetic sequence of the nematode's mitochondria.
(D) Mapping the neural pathways controlling tail movement.

2025

116. What can be inferred from the discovery that phytoparasitic nematodes possess genes of bacterial or fungal origin?
(A) Nematodes are essentially a type of bacteria.
(B) The sequencing machines were contaminated with soil microbes.
(C) Horizontal gene transfer (HGT) played a crucial role in the evolution of plant parasitism in nematodes.
(D) Nematodes frequently interbreed with soil fungi.

2023

117. Which definition correctly describes an "effector" in the context of nematode-plant interactions?
(A) A secreted molecule that modulates host physiology or suppresses defenses to aid parasitism.
(B) A chemical pesticide applied by farmers that takes effect quickly.
(C) The physical stylet used to pierce the plant cell wall.
(D) A transcription factor inside the plant that initiates cell death.

2011

118. Which of the following is a significant milestone in nematode genomics?
(A) Meloidogyne incognita was the first plant-parasitic nematode to have its entire genome completely deleted via CRISPR.
(B) The C. elegans genome was successfully sequenced only after plant-parasitic genomes

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2018

102. Comparing in vitro RNAi to Host-Induced Gene Silencing (HIGS), what is the key difference in delivery?
(A) HIGS involves spraying dsRNA on the soil, while in vitro RNAi injects dsRNA into the plant stem.
(B) HIGS requires the use of soil fumigants as a carrier, while in vitro RNAi uses plain water.
(C) There is no difference; both terms refer to the exact same methodology.
(D) HIGS engineers the host to produce dsRNA which the nematode ingests while feeding.

2016

103. Which feature is most relevant when selecting a target gene for RNAi in nematodes?
(A) The gene must be involved in non-essential pathways like pigment formation.
(B) The gene must be essential for survival and lack homology to non-target organisms.
(C) The gene shares a high sequence similarity with beneficial human genes.
(D) The gene must exclusively encode for acetylcholinesterase.

2006

104. What can be inferred about the future of HIGS given its specificity?
(A) It will likely harm all beneficial insects visiting the plant.
(B) It will completely replace the need for traditional plant breeding within two years.
(C) It offers a highly targeted approach that minimizes off-target environmental effects compared to broad-spectrum chemicals.
(D) It is ineffective against endoparasitic nematodes because they do not feed on plant cells.

2008

105. Which definition correctly outlines the role of plant proteinase inhibitors (PIs) in transgenic crops for nematode control?
(A) PIs are enzymes that degrade the nematode's DNA.
(B) PIs form a physical wall around the root cap.
(C) PIs are volatile compounds emitted by leaves to repel nematodes.
(D) PIs bind to and inhibit digestive proteases, leading to amino acid starvation.

2022

106. Which of the following identifies a well-known lectin used in transgenic research against nematodes?
(A) Snowdrop lectin (GNA)
(B) Cry1Ac
(C) Acetylcholinesterase
(D) Succinate dehydrogenase

2014

107. Which of the following is a factual statement regarding the deployment of Bacillus thuringiensis (Bt) Cry proteins for nematode management?
(A) The exact same Cry proteins used against lepidopteran insects are always highly effective against nematodes.
(B) Nematode-specific Cry proteins (like Cry5B) must be used because nematodes are functionally different from insects.
(C) Bt proteins only work if applied as a gas.
(D) Transgenic Bt crops for nematodes are currently the most widely planted commercial crops globally.

2001

108. Identify the correct statement regarding the mechanism of Bt Cry proteins in nematodes.
(A) They inhibit the molting cycle by targeting chitin synthesis.
(B) Ingested proteins bind to intestinal receptors, forming pores that lead to cell lysis.
(C) They silence RNA transcripts inside the nematode gonads.
(D) They act purely as feeding deterrents without causing mortality.

NODIA

2015

109. Which statement INCORRECTLY describes transgenic approaches to nematode management?
(A) Transgenic plants expressing PIs show complete, 100% immunity and instant death to all invading nematodes.
(B) Transgenic plants can be engineered to express anti-nematode peptides.
(C) Regulatory approval and public acceptance are significant hurdles for deploying transgenic anti-nematode crops.
(D) Lectins engineered into plants can disrupt nematode feeding and sensory perception by binding to carbohydrates.

2010

110. Consider the following statements about RNAi and HIGS:
I. RNAi utilizes double-stranded RNA (dsRNA) as the trigger molecule.

2003

126. Comparing C. elegans to Meloidogyne species in genomic terms, which of the following is true?
(A) C. elegans possesses a massive repertoire of plant cell wall-degrading enzymes, unlike Meloidogyne.
(B) C. elegans has a completely unsequenced genome, while Meloidogyne is the universal model.
(C) Meloidogyne lacks many metabolic pathways, reflecting its obligate parasitic lifestyle.
(D) Both possess an identical number of genes related to sensory amphid function.

2009

127. Which feature is most relevant for identifying a novel molecular target for bionematicides?
(A) The target must be universally present in humans, plants, and insects.
(B) The target should be located exclusively in the nematode's cuticle.
(C) The target should strictly control the color of the nematode.
(D) The target should be an essential enzyme that is divergent in non-target organisms.

2013

128. What can be inferred about the evolutionary origin of the parasitome based on transcriptomic studies?
(A) It evolved entirely from genes inherited from the nematode's vertebrate ancestors.
(B) It was entirely synthesized de novo when the nematodes first encountered agriculture 10,000 years ago.
(C) It involves repurposed ancestral genes and genes acquired via horizontal transfer.
(D) It is an illusion caused by sequencing errors in early genomic studies.

2024

129. Which definition best describes a 'trap crop' when used in an INM module?
(A) A crop that yields highly valuable traps for catching rodents.
(B) A highly susceptible plant grown to attract nematodes, which is destroyed before the nematodes can complete their life cycle.
(C) A crop genetically engineered to secrete synthetic pesticides.
(D) A plant that completely repels all insects and nematodes simultaneously.

2024

130. Consider the following statements regarding nematode management methods:
I. Summer ploughing reduces nematode load through desiccation and thermal death.
II. Hot water treatment is commonly used for sterilizing field soils on a massive scale.
III. Trap crops must be carefully timed for destruction to prevent them from becoming breeding grounds.
IV. Crop rotation with non-hosts starves obligate plant-parasitic nematodes.
V. Tagetes (marigold) secretes alpha-terthienyl which has nematicidal properties.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, IV and V

2022

131. Which of the following identifies the primary reason Methyl Bromide was phased out under the Montreal Protocol?
(A) It was heavily depleting the Earth's stratospheric ozone layer.
(B) It was highly ineffective against root-knot nematodes.
(C) It caused immediate necrosis in all crops it was applied to.
(D) It was too expensive to manufacture compared to Organophosphates.

2024

132. Which of the following is a factual statement regarding the "bare-root dip" method?
(A) It is most appropriately used for direct-seeded crops like wheat and barley.
(B) It is most appropriately used for mature, fruit-bearing mango trees.
(C) It is most appropriately used for transplanted crops such as tomato, brinjal, or fruit tree seedlings.
(D) It is most appropriately used for large-scale cereal farming via aerial spraying.

2002

133. Identify the correct statement regarding the Mi gene in tomato.
(A) The Mi gene was originally transferred to cultivated tomato from the wild species Solanum peruvianum.
(B) The Mi gene is effective against all species of root-knot nematodes globally.
(C) The Mi gene acts by preventing juvenile nematodes from penetrating the root epidermis.
(D) Resistance provided by the Mi gene is

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List II: (Nature/Mode of Action)
1. Fungal predator using adhesive nets
2. Succinate dehydrogenase inhibitor (SDHI)
3. Chloride channel activator derived from fermentation
4. Precursor to methyl isothiocyanate (MITC) gas

(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-2, R-3, S-4

2012

151. Which feature is most relevant to the success of HIGS against plant-parasitic nematodes?
(A) The dsRNA must be highly volatile to act as a soil fumigant.
(B) The plant must produce the dsRNA in specific root tissues where the pest feeds.
(C) The plant must shed its roots immediately upon infection.
(D) The dsRNA must target a gene that is only present in the plant itself.

2003

152. What can be inferred from the use of RNAi to silence a nematode gene coding for an essential major sperm protein (MSP)?
(A) The nematode will become highly virulent and destroy the plant faster.
(B) The nematode will instantly die before entering the root.
(C) The female nematodes will be unable to produce fertilized eggs, leading to population decline.
(D) The nematode will switch to a purely parthenogenetic mode of reproduction and thrive.

2022

153. Which definition applies to the Mi-1.2 gene structurally?
(A) It is a simple enzyme that degrades chitin.
(B) It is a transcription factor that regulates photosynthesis.
(C) It is a synthetic chemical compound patented by a seed company.
(D) It is a member of the nucleotide-binding leucine-rich repeat (NLR) class of plant resistance genes.

2003

154. Which of the following matches the resistant variety with its crop and nematode target?
(A) Hisar Lalit - Tomato - Root-knot nematode
(B) Kufri Jyoti - Potato - Potato Cyst Nematode
(C) Pusa Ruby - Tomato - Root-knot nematode
(D) Sonalika - Wheat - Ear cockle nematode

2015

155. Which of the following is a factual statement regarding how the Hs1pro-1 gene confers resistance in sugarbeet?
(A) By repelling the juveniles from the root surface entirely.
(B) By degrading the syncytium after initial formation, leading to starvation and a shift towards male development.
(C) By producing acute toxins that dissolve the nematode upon contact.
(D) By preventing the seeds from germinating if nematodes are present.

2006

156. Identify the correct statement regarding crop rotation for nematode management.
(A) Rotating between different highly susceptible varieties of the same crop effectively controls nematodes.
(B) Effective crop rotation requires alternating a susceptible crop with a non-host or highly resistant crop to disrupt the nematode's life cycle.
(C) Crop rotation is highly effective for controlling free-living saprophytic nematodes.
(D) A single season of non-host rotation permanently eradicates all nematodes from the field.

2023

157. Which statement INCORRECTLY characterizes the use of fallowing?
(A) Fallowing is universally adopted because it maximizes farmer income during the fallow period.
(B) Fallowing reduces populations of obligate plant-parasitic nematodes through starvation.
(C) Clean fallowing (maintaining weed-free fields) is necessary for success.
(D) Fallowing can leave soil vulnerable to erosion if not managed properly.

NODIA

2025

158. What is the conceptual objective of "Integrated" Nematode Management (INM)?
(A) To synthesize a single perfect chemical compound.
(B) To legally integrate farms into large corporate holdings to afford fumigation.

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(A) The physical process of nematodes migrating through the soil.
(B) The genetic mutation of nematodes rendering them immune to chemicals.
(C) The application of nematicides to the soil through irrigation water.
(D) The use of hot water to treat infected plant roots.

2012

143. Which of the following reflects the role of the Plant Quarantine Order (PQO) in India?
(A) It strictly prohibits the export of all Indian agricultural products.
(B) It dictates the domestic prices of nematicides.
(C) It enforces the mandatory use of chemical fertilizers on all farms.
(D) It regulates the import of agricultural commodities to prevent the entry, establishment, and spread of exotic pests and diseases.

2017

144. Which of the following is a factual statement regarding the nematode causing the "Golden Nematode" issue in the Nilgiris?
(A) It is Meloidogyne incognita.
(B) It is Radopholus similis.
(C) It is Globodera rostochiensis.
(D) It is Tylenchulus semipenetrans.

2005

145. Identify the correct statement regarding Pest Risk Analysis (PRA).
(A) It is a purely qualitative process with no scientific guidelines.
(B) It evaluates pest entry, establishment, and spread likelihood and economic impact.
(C) It is only conducted for insect pests, not plant-parasitic nematodes.
(D) It requires the experimental introduction of the pest into the country to assess actual damage.

2008

146. Which statement INCORRECTLY details international phytosanitary certification?
(A) It is essentially a "passport" for plants and plant products in international trade.
(B) The certificate confirms that the consignment complies with the importing country's phytosanitary requirements.
(C) The exporting country's NPPO is responsible for issuing the certificate.
(D) An international phytosanitary certificate completely overrides and nullifies the importing country's quarantine laws.

2019

147. What is the conceptual difference between a pre-infectional and post-infectional defense mechanism?
(A) Pre-infectional mechanisms exist constitutively before nematode attack, while post-infectional mechanisms are activated in response to nematode penetration.
(B) Pre-infectional mechanisms are chemical; post-infectional are structural.
(C) Pre-infectional defenses only work against fungi; post-infectional work against nematodes.
(D) Pre-infectional defenses are found in susceptible plants, while post-infectional are only in non-hosts.

NODIA

2024

148. In a cause-and-effect biological interaction, what triggers the hypersensitive response (HR) in a resistant plant?
(A) The physical tearing of the cell wall by the nematode's stylet.
(B) A sudden drop in soil temperature.
(C) Recognition of specific nematode-associated molecular patterns or effectors (Avr products) by the plant's resistance (R) proteins.
(D) The accumulation of high levels of synthetic nematicides in the root.

2010

149. How are root exudates functionally classified in host finding by nematodes?
(A) As long-distance attractants (kairomones) that guide infective juveniles toward the root tips.
(B) As strictly nematicidal toxins in all plant species.
(C) As physical barriers that harden the soil around the root.
(D) As enzymes that digest the nematode cuticle.

2015

150. Match the nematode management agent or chemical in List I with its specific nature or mode of action in List II.
List I: (Agent/Chemical)
P. Abamectin
Q. Arthrobotrys oligospora
R. Metam sodium
S. Fluopyram

endospores adhering to the cuticle of the juvenile nematodes.
(D) The nematodes become extremely fast and hyperactive.

2023

185. What can be inferred about the host specificity of Pasteuria penetrans?
(A) It attacks every species of nematode in the soil equally.
(B) It only attacks free-living saprophytic nematodes and ignores plant parasites.
(C) It requires an intermediate insect host to complete its life cycle.
(D) It exhibits a high degree of specificity with biotypes only adhering to specific populations.

2009

186. Which definition accurately describes a "suppressive soil" in nematology?
(A) Soil where pests fail to establish due to natural enemies.
(B) A soil type that has been completely sterilized by chemical fumigation.
(C) A highly compacted clay soil where nematodes are physically crushed.
(D) A soil with a pH below 4.0 that chemically burns nematode cuticles.

2022

187. Why is crop rotation often ineffective against Meloidogyne incognita in many mixed-cropping regions?
(A) Because it is a highly specialized parasite with only one host.
(B) Because its wide and polyphagous host range makes finding non-host crops difficult.
(C) Because crop rotation actually stimulates its reproduction.
(D) Because M. incognita survives as a dormant cyst for 20 years.

2004

188. Which of the following is a factual statement regarding the "gelatinous matrix" produced by root-knot nematodes?
(A) It serves to dissolve the plant cell wall for feeding.
(B) It serves to protect the extruded eggs from desiccation, microbial attack, and some chemical nematicides.
(C) It serves to paralyze predatory nematodes in the soil.
(D) It serves to act as a venom injected into the plant vascular system.

2005

189. Identify the correct statement regarding the application of host resistance in INM.
(A) Rotating varieties with non-hosts prevents selection of resistance-breaking biotypes.
(B) Continuous planting of a single resistant variety forever is the core of INM.
(C) Host resistance is totally useless if biological controls are applied.
(D) Resistant varieties always yield 50% less than susceptible varieties.

2004

190. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Transgenic crops expressing double-stranded RNA (dsRNA) against essential nematode genes show significant resistance to nematode infection.
Reason (R): The ingested dsRNA triggers the nematode's RNA interference (RNAi) machinery, selectively silencing the target gene and disrupting vital biological processes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

191. What is the conceptual goal of using a "catch crop" strategy?
(A) To maximize the crop yield for market sale.
(B) To catch airborne spores of nematophagous fungi.
(C) To use deep roots to bring leached nutrients back to the surface.
(D) To induce hatching and then destroy the crop early.

2008

192. In a cause-and-effect relationship, how does increasing soil organic matter affect plant-parasitic nematode populations?
(A) It severely increases plant-parasitic nematodes because they directly feed on decomposing organic matter.
(B) It turns the soil completely anaerobic, killing the host plant.
(C) It generally reduces impact by boosting plant vigor and fostering diverse natural enemies.

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(C) To combine multiple tactics to manage pests sustainably.
(D) To use only biological controls regardless of the economic threshold.

2005

159. In an INM module for root-knot nematodes in protected agriculture (polyhouses), which combination represents a rational cause-and-effect approach?
(A) Deep summer ploughing inside the polyhouse during winter, followed by continuous cropping of susceptible tomatoes.
(B) Flooding the polyhouse for three months, then immediately planting dryland crops.
(C) Applying maximum doses of organophosphates daily to ensure sterile soil.
(D) Using solarization followed by enriched FYM and growing tolerant plant varieties.

2005

160. How are root-lesion nematodes (Pratylenchus spp.) biologically classified in relation to plant roots?
(A) Sedentary endoparasites
(B) Ectoparasites
(C) Migratory endoparasites
(D) Semi-endoparasites

2009

161. Comparing sedentary endoparasites (Meloidogyne) to migratory endoparasites (Pratylenchus), what is a key difference in their feeding strategy?
(A) Meloidogyne destroys cells as it moves continually; Pratylenchus establishes a permanent specialized feeding site.
(B) Meloidogyne induces giant cells, while Pratylenchus creates cortical necrotic lesions.
(C) Meloidogyne only feeds on the root hairs from the outside; Pratylenchus feeds deep within the vascular tissue.
(D) There is no difference; both induce syncytia.

2007

162. Which feature is most relevant to the action of Fluensulfone, a newer nematicide?
(A) It requires conversion into MITC gas.
(B) It acts as an SDHI in the mitochondria.
(C) It is an extract of the neem tree.
(D) It causes rapid inhibition of development and locomotion without inhibiting AChE.

2008

163. What can be inferred about systemic non-fumigants applied as foliar sprays?
(A) Most have strong acropetal movement but weak basipetal movement, making foliar use poor.
(B) They are highly effective because they primarily move basipetally (downward) in the phloem to reach the roots in lethal concentrations.
(C) They evaporate off the leaves and act as a gas canopy.
(D) They are specifically designed to only control foliar nematodes like Aphelenchoides.

2003

164. Which definition precisely describes a "nematistat"?
(A) A chemical that instantly ruptures the nematode's cell membranes, causing immediate death.
(B) An instrument used to extract nematodes from soil samples.
(C) A compound that paralyzes or disorients nematodes without directly killing them, though prolonged exposure may lead to death via starvation.
(D) A regulatory threshold level for nematode quarantine.

NODIA

2017

165. Which of the following is the primary reason for targeting messenger RNA (mRNA) transcripts during RNA interference (RNAi) inside the nematode?
(A) The messenger RNA (mRNA) transcript of a specific gene
(B) The cell wall
(C) The stylet knob
(D) The mitochondria

2014

166. Which of the following is a factual statement regarding genetic terminology in nematode resistance?
(A) The term 'virulence' refers to the ability of a plant to resist a specific nematode species.
(B) The term 'virulence' refers to the toxicity level of a chemical nematicide.
(C) The term 'virulence' refers to the rate at which nematodes swim through soil water.
(D) The term 'virulence' refers to the ability of a nematode population to reproduce on a resistant plant variety.

2019

167. Identify the correct statement regarding nematode biotypes or pathotypes.

2022

201. Identify the correct statement regarding nematode genomics.
(A) The genome of Meloidogyne incognita is highly compact and entirely diploid.
(B) Whole-genome sequencing is completely useless for identifying chemical targets.
(C) Caenorhabditis elegans possesses exactly the same set of parasitism genes as Globodera pallida.
(D) Genomics reveals unique genes in parasitic nematodes likely acquired via horizontal transfer.

2005

202. Which statement INCORRECTLY characterizes the use of C. elegans as a model organism in nematology?
(A) Because it is a devastating plant parasite, studying its root-invasion mechanisms is highly applicable.
(B) It is easy and inexpensive to culture in the laboratory.
(C) It has a fully sequenced genome and a mapped nervous system.
(D) Its genetic pathways for basic development and neurotransmission are heavily utilized to screen broad-spectrum nematicides.

2022

203. What is the conceptual advantage of Host-Induced Gene Silencing (HIGS) over transgenic application of Bt toxins?
(A) HIGS completely eliminates the need for crop irrigation.
(B) HIGS uses small specific RNA molecules to minimize off-target environmental effects.
(C) HIGS causes the plant to become highly toxic to all mammals.
(D) Bt toxins act instantly, whereas HIGS never provides actual field resistance.

2018

204. In a cause-and-effect relationship, what occurs when a plant successfully mounts a hypersensitive response against Meloidogyne?
(A) The nematode juvenile successfully establishes a giant cell but is unable to lay eggs.
(B) Targeted necrosis prevents the establishment of giant cells and starves the infective J2.
(C) The entire root system instantly dies.
(D) The nematode transforms into a cyst.

2004

205. How are the defensive chemicals known as "phytoalexins" classified temporally during an infection?
(A) Induced (Post-infectional)
(B) Constitutive (Pre-infectional)
(C) Exudative
(D) Systemic acquired

2023

206. Comparing trap crops to non-host crops, what is the primary physiological difference regarding nematode infection?
(A) Non-hosts allow penetration but prevent reproduction; trap crops physically repel nematodes.
(B) Trap crops are always highly resistant genetically, while non-hosts are susceptible but planted out of season.
(C) Trap crops attract and allow penetration before early destruction; non-hosts prevent it entirely.
(D) There is no difference; the terms are perfectly synonymous.

2019

207. Which feature is most relevant to the efficacy of deep summer ploughing?
(A) The presence of heavy monsoon rains during the ploughing period.
(B) Applying it exclusively in dense, shaded orchards.
(C) Doing it primarily at night to avoid solar radiation.
(D) Maximum daytime temperatures exceeding 40°C and very low soil moisture.

2004

208. What can be inferred about a nematode population if the damage coefficient in an EIL calculation is very high?
(A) The nematode causes very little damage per individual, so the EIL will be high.
(B) The nematode population is entirely beneficial.
(C) High yield loss per individual nematode results in a correspondingly low Economic Injury Level.
(D) The crop is highly resistant and immune to damage.

2022

209. Which definition precisely describes a "bionematicide"?
(A) A highly persistent, synthetic halogenated hydrocarbon.

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(D) They are specialized mycelial loops that physically inflate to trap passing nematodes.

2009

176. Which of the following identifies the primary reason Methyl Bromide was phased out under the Montreal Protocol?
(A) Ammonia
(B) Acetic acid
(C) Isothiocyanates (derived from glucosinolates)
(D) Hydrogen cyanide

2016

177. Which of the following is a factual statement regarding the technique utilizing cruciferous plant residues to release toxic volatiles in the soil?
(A) It is known as biofumigation.
(B) It is known as solarization.
(C) It is known as chemigation.
(D) It is known as bioremediation.

2006

178. Identify the correct statement regarding biofumigation.
(A) It involves pumping synthetic methyl bromide gas under a plastic tarp.
(B) It is only effective against foliar fungal diseases.
(C) It permanently sterilizes the soil, killing all beneficial microbes.
(D) It uses enzymatic breakdown of glucosinolates into toxic soil-borne isothiocyanates.

2024

179. Which statement INCORRECTLY characterizes the use of oil cakes as organic soil amendments?
(A) They act instantaneously as contact poisons within minutes of application to the soil surface.
(B) They improve soil structure and water-holding capacity.
(C) They release nematicidal byproducts such as fatty acids, phenols, and ammonia during microbial decomposition.
(D) They stimulate the proliferation of natural nematode enemies like predatory nematodes and nematophagous fungi.

2009

180. What is the conceptual mechanism by which green manuring controls nematodes?
(A) The green plants physically block the nematodes from moving in the soil.
(B) The green color of the manure reflects UV light into the soil, blinding the nematodes.
(C) Incorporation of biomass releases toxic organic acids and stimulates antagonistic soil flora.
(D) The manure absorbs all available nitrogen, starving the nematodes.

2017

181. In an integrated management module, why might an application of a biological control agent fail?
(A) Poor formulation, harsh environmental conditions (extreme heat/dryness), or incompatibility with simultaneously applied chemical pesticides.
(B) Because biological agents are inherently synthetic.
(C) Because biological agents multiply too rapidly and consume the crop.
(D) Because biological agents only work in sterile environments.

NODIA

2018

182. How are the subventral esophageal glands of root-knot nematodes developmentally classified during the infection process?
(A) They are highly active during the entire life cycle of the adult female.
(B) They only become active after the nematode has laid eggs.
(C) They strictly produce the gelatinous matrix for the egg mass.
(D) They are active in pre-parasitic stages to secrete cell wall-degrading enzymes.

2017

183. Comparing the dorsal to the subventral esophageal glands in sedentary endoparasites, what functional shift occurs?
(A) The dorsal gland shrinks, and subventral glands enlarge during adult development.
(B) Subventrals are active during migration, while the dorsal maintains feeding sites later.
(C) Both glands produce exactly the same enzymes at all times.
(D) The dorsal gland secretes digestive enzymes, while the subventrals secrete structural cuticular proteins.

2016

184. Which feature is most relevant to identifying Pasteuria penetrans infection in a nematode population?
(A) The nematodes turn visibly bright red.
(B) The nematodes develop a massive fungal mycelial network exiting their bodies.
(C) The presence of numerous saucer-shaped

(A) They are morphologically distinct species.
(B) They are populations of a nematode species capable of breaking the resistance of specific host cultivars.
(C) They are exclusively beneficial nematodes used in biological control.
(D) They denote the color variations observed in cyst nematodes.

2008

168. Which statement INCORRECTLY characterizes phytosanitary certification?
(A) It is based on visual inspections, sampling, and sometimes specific laboratory testing.
(B) It facilitates safer international trade of agricultural commodities.
(C) It provides a 100% guarantee that the shipment is completely free of all known microbes.
(D) It addresses specific quarantine pests regulated by the importing country.

2005

169. What is the conceptual reason for imposing a domestic quarantine in the Nilgiris?
(A) The cool, temperate climate of the Nilgiris is the only place potatoes can grow in India.
(B) To restrict the movement of chemical pesticides out of the region.
(C) To protect the endemic potato cyst nematode from extinction.
(D) To prevent the spread of the potato cyst nematode into major potato-growing zones.

2011

170. In a cause-and-effect relationship, how does deep summer ploughing specifically reduce nematode populations?
(A) It turns the soil over, bringing deep-dwelling nematodes and eggs to the surface where they are killed by solar radiation and dry wind.
(B) It mixes the nematodes deeper into the soil where it is cooler and they freeze.
(C) It causes the nematodes to instantly hatch and migrate away.
(D) It completely sterilizes the soil of all bacteria, depriving nematodes of their food source.

2001

171. How are bio-rational pesticides generally classified in terms of their environmental impact?
(A) Highly persistent and bioaccumulative.
(B) Low toxicity to non-target organisms, rapidly degrading, and having minimal environmental impact.
(C) Broad-spectrum biocides that sterilize the environment.
(D) Synthetic heavy metals.

2009

172. Comparing classical nematicides (like Aldicarb) to modern bio-rationals (like Fluopyram/ Abamectin), what is a major regulatory trend?
(A) Classical nematicides are being encouraged due to their cheap cost, while bio-rationals are being banned.
(B) Highly toxic chemicals are being phased out in favor of target-specific bio-rationals.
(C) Both are currently banned globally without exception.
(D) Modern bio-rationals are being phased out because they are too toxic to humans.

2003

173. Which feature is most relevant to the successful application of granular nematicides?
(A) Incorporating them uniformly into the soil followed by light irrigation to dissolve and distribute the active ingredient.
(B) Applying them on windy days to ensure dispersal.
(C) Applying them to dry, crusted soil surfaces without incorporation.
(D) Mixing them with strong alkaline fertilizers before application.

2003

174. What can be inferred about the use of Bacillus thuringiensis (Bt) against plant-parasitic nematodes compared to insects?
(A) It is much easier to apply Bt to nematodes because they live on the leaves.
(B) Bt is universally ineffective against all nematode species.
(C) Narrow stylet orifices limit protein uptake, necessitating transgenic delivery methods.
(D) Bt toxins must be applied as a soil fumigigant to work on nematodes.

2009

175. Which definition correctly outlines the function of nematode-trapping fungi's "constricting rings"?
(A) They are reproductive spores that explode upon contact.
(B) They are chemical halos secreted into the soil to repel nematodes.
(C) They are physical barriers wrapped around the plant root.

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(D) It creates a physical barrier that prevents nematodes from hatching.

2012

193. How are nematicides classified based on their movement within the plant?
(A) Volatile and Non-volatile
(B) Systemic and Non-systemic
(C) Contact and Fumigant
(D) Organic and Inorganic

2006

194. Comparing an Emulsifiable Concentrate (EC) to a Wettable Powder (WP) formulation, which is generally true for nematicidal applications?
(A) WPs are highly volatile gases, while ECs are solid blocks.
(B) ECs are strictly used for seed treatments, while WPs are for chemigation.
(C) There is no physical difference when mixed with water.
(D) ECs form a true solution in water, while WPs form a suspension that requires continuous agitation to prevent settling.

2017

195. Which feature is most relevant when considering chemigation for nematicide application?
(A) The use of anti-siphon backflow devices to prevent primary water source contamination.
(B) The requirement for high-speed wind to disperse the chemical.
(C) The use of entirely solid, insoluble chemical pellets.
(D) The need to apply the chemical at midnight.

2022

196. What can be inferred if an acetylcholinesterase inhibitor (carbamate) fails to control a nematode population after repeated, long-term use?
(A) The soil has become too alkaline.
(B) The nematodes have mutated to digest the chemical as food.
(C) Successive use may cause enhanced microbial degradation which reduces field efficacy.
(D) The chemical has spontaneously converted into a fumigant.

2007

197. Which definition accurately characterizes the "hypersensitive response" (HR)?
(A) Rapid localized cell death at the infection site that restricts nutrient spread to the pest.
(B) A generalized slow decline of the plant due to lack of water.
(C) A systemic over-reaction of the plant to synthetic fertilizers resulting in leaf burn.
(D) The nematode's toxic reaction to biological control agents.

NODIA

2004

198. In the context of plant-nematode interactions, what does the 'gene-for-gene' hypothesis state?
(A) Every plant has one gene for yield and one for height.
(B) Nematodes can swap genes with the plant randomly.
(C) Chemical resistance is dictated by a single universal gene.
(D) For every dominant resistance gene (R) in the host, there is a corresponding dominant avirulence gene (Avr) in the pathogen/ nematode.

2024

199. Which of the following is a factual statement regarding the mode of action of Spirotetramat?
(A) It involves inhibition of acetylcholinesterase.
(B) It involves inhibition of lipid biosynthesis and reproduction, acting as a two-way systemic agent.
(C) It involves direct physical desiccation of the nematode cuticle.
(D) It involves generation of lethal MITC gas in the soil.

2003

200. Match the biotechnological or genomic term in List I with its correct definition in List II.
List I: (Term)
P. HIGS
Q. Transcriptome
R. Effector
S. RNAi
List II: (Definition)
1. Mechanism of post-transcriptional gene silencing using dsRNA
2. Parasitism protein secreted to modulate host defenses
3. Complete set of RNA transcripts in a cell or tissue
4. Delivery of silencing RNA via the engineered host plant
(A) P-4, Q-3, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

enhanced at soil temperatures above 35°C.

2007

134. Which statement INCORRECTLY characterizes the use of organic amendments like neem cake?
(A) They improve overall soil health and microbial diversity.
(B) They provide plant nutrients in addition to their nematicidal effects.
(C) Their nematicidal effect is mediated by decomposition products and active principles like azadirachtin.
(D) They offer instant, 100% knockdown of nematode populations comparable to methyl bromide.

2002

135. What is the conceptual basis for considering the C:N ratio of organic amendments in nematode management?
(A) It dictates the color of the amendment.
(B) Low C:N ratios lead to rapid decomposition and quick release of nematicidal ammonia.
(C) Only amendments with a C:N ratio of exactly 1:1 can kill nematodes.
(D) The C:N ratio determines if the amendment will act as a fumigant or contact poison.

2010

136. In a cause-and-effect relationship, how does the application of Pseudomonas fluorescens protect roots?
(A) It enters the plant vascular system and travels to the leaves to kill foliar nematodes.
(B) It alters the soil structure to become solid rock, preventing nematode movement.
(C) It colonizes the rhizosphere and releases metabolites that repel or harm nematodes.
(D) It absorbs all soil moisture, starving the nematodes of water.

2024

137. How are Pasteuria penetrans biologically classified?
(A) A predacious soil fungus
(B) A free-living predatory nematode
(C) A synthetic biological chemical
(D) A mycelial, endospore-forming, obligate bacterial parasite of nematodes.

2007

138. Comparing Pochonia chlamydosporia to Purpureocillium lilacinum, which of the following is true?
(A) Both are primarily known as parasites of nematode eggs and sedentary females.
(B) Pochonia is a bacterium, while Purpureocillium is a fungus.
(C) Pochonia captures nematodes with rings, while Purpureocillium uses adhesive nets.
(D) Neither has any practical application in biological control.

2025

139. Which feature is most relevant to the efficacy of soil solarization?
(A) Applying it during the coldest months of winter to freeze the soil.
(B) Using transparent polyethylene during peak solar periods to maximize heat trapping.
(C) Ensuring the soil is completely dry and heavily shaded.
(D) Leaving the plastic on the soil for a maximum of 24 hours.

2018

140. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Organophosphate and carbamate nematicides act reversibly or irreversibly by binding to the enzyme acetylcholinesterase in nematodes.
Reason (R): Inhibition of acetylcholinesterase prevents the breakdown of acetylcholine, leading to continuous nerve impulse transmission and paralysis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

141. What can be inferred from the need for a 'waiting period' after soil fumigation with 1,3-Dichloropropene?
(A) Time is required for the toxic gas to dissipate from the soil to prevent phytotoxicity to the newly planted crop.
(B) The chemical takes several weeks to become volatile.
(C) The nematodes need time to migrate into the treated area to be killed.
(D) The soil needs to cool down from the heat generated by the chemical reaction.

2022

142. Which definition strictly applies to the term "nemigation"?

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(B) A formulated product containing a biological agent used to manage nematode populations.
(C) A toxic gas used for soil fumigation.
(D) A mechanical tool used to chop roots.

2004

210. Consider the following statements regarding nematode sampling:
I. Samples should ideally include both soil and feeder roots.
II. Samples must be kept cool (e.g., in a cooler box) and moist during transit to the lab.
III. Sampling exclusively the dry, top 2 cm of soil provides the best estimate of root-knot populations.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2008

211. Which of the following identifies a major source of resistance to Globodera pallida?
(A) Wild potato species such as Solanum tuberosum ssp. andigena and S. vernei
(B) The Mi gene
(C) The Hs1pro-1 gene
(D) Tagetes patula

2009

212. Which of the following is a factual statement regarding the volume of water used when applying contact nematicides?
(A) The water chemically neutralizes the active ingredient to prevent plant death.
(B) High volumes of water cause the chemical to evaporate faster.
(C) The water acts as the vehicle to distribute the chemical down into the root zone where the nematodes reside.
(D) Water causes the nematodes to float to the soil surface to be exposed to sunlight.

2021

213. Identify the correct statement regarding the mechanism of Azadirachtin.
(A) It disrupts nematode molting, acts as a feeding deterrent, and reduces egg hatching.
(B) It acts purely as an organophosphate.
(C) It acts as a highly volatile soil fumigant.
(D) It creates a solid physical barrier around the plant root.

2018

214. Which statement INCORRECTLY details the use of crop rotation for managing Potato Cyst Nematode (PCN)?
(A) Crop rotation is a cornerstone of PCN management due to the narrow host range of the nematode.
(B) Rotating potatoes with non-host crops like cereals or pasture grasses helps steadily decline the cyst population in the soil.
(C) Prolonged absence of a host crop causes PCN eggs to eventually die from starvation or natural antagonists.
(D) A single season of non-host rotation is sufficient to completely eradicate PCN from a field.

2012

215. What is the conceptual aim of phytosanitary regulations like the Plant Quarantine Order?
(A) To increase the price of local agricultural commodities.
(B) To prevent the introduction, establishment, and spread of exotic pests across borders.
(C) To mandate the use of organic farming practices nationally.
(D) To ensure that all imported fruits are perfectly spherical.

2014

216. In a cause-and-effect relationship, why is Pseudomonas fluorescens often applied as a seed treatment?
(A) It provides a dense cloud of fumigant gas around the seed.
(B) It permanently alters the DNA of the seed.
(C) It colonizes the emerging radicle to provide early protection against invading nematodes.
(D) It prevents the seed from germinating if the soil is too dry.

2015

217. How are nematicidal essential oils (e.g., from garlic or thyme) broadly classified?
(A) Synthetic organophosphates
(B) Traditional soil fumigants
(C) Predatory biocontrols
(D) Bio-rational/botanical nematicides

2025

218. Comparing the nematicidal efficacy of different organic amendments, what role does the C:N ratio play?
(A) Low C:N ratios release ammonia rapidly, while high C:N materials lead to nitrogen immobilization.

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expression.
(C) Adult females show high expression of locomotion genes, while J2s show high expression of reproductive genes.
(D) J2 transcriptomes completely lack any effector genes.

2010

267. Which feature is most relevant when identifying a suitable molecular target for a novel bionematicide?
(A) The gene must be present in all living organisms, including humans.
(B) The target should be essential for viability but highly divergent in non-target species.
(C) The target must be an obscure gene with no known biological function.
(D) The target must solely control the color pigmentation of the nematode.

2025

268. What can be inferred about the genetic diversity of root-knot nematodes based on their genomic analysis?
(A) They are genetically completely homogeneous clones with zero variation.
(B) Asexual species show genomic complexity and expansions explaining their wide host range.
(C) They have the smallest, simplest genome of any known animal.
(D) Their genetic diversity is strictly limited to a single chromosome.

2005

269. Which definition precisely describes the term "Parasitome"?
(A) The complete repertoire of proteins and molecules secreted by a parasite to facilitate the infection and manipulation of its host.
(B) The physical swelling on a root caused by a nematode.
(C) A chemical pesticide used exclusively against parasites.
(D) The community of hyper-parasites living on a nematode.

2025

270. Which of the following reflects the status of methyl bromide under international law?
(A) It is currently the most highly recommended nematicide globally.
(B) It was banned solely because it was too expensive to manufacture.
(C) Soil fumigation use was phased out under the Montreal Protocol due to ozone depletion.
(D) It is only permitted for use in organic farming.

2012

271. Which of the following is a factual statement regarding the graphical representation of the "Economic Threshold Level"?
(A) It is the point where the yield loss curve crosses the zero mark.
(B) It is the point where the nematode population reaches absolute zero.
(C) It is the point where the cost of the crop seed exceeds its market value.
(D) It is the point where the cost of pest control equals the value of the yield saved by that control.

2012

272. Identify the correct statement regarding the interaction between Pseudomonas spp. and plant-parasitic nematodes.
(A) Pseudomonas bacteria actively hunt down and devour adult nematodes.
(B) They cause the plant roots to rot, starving the nematodes.
(C) They suppress nematodes by producing secondary metabolites and inducing host resistance.
(D) They serve as an obligate intermediate host for the nematode.

NODIA

2005

273. Which statement INCORRECTLY characterizes the use of trap crops like Crotalaria spectabilis?
(A) They are highly attractive to Meloidogyne juveniles.
(B) The crop must be left in the field permanently to continuously kill nematodes without any human intervention.
(C) The juveniles penetrate the roots but fail to develop into reproductive adults due to inherent resistance mechanisms.
(D) They effectively act as a "dead end" for the trapped nematode population.

2004

274. What is the conceptual advantage of using Pasteuria penetrans as a biological control agent?
(A) It is a broad-spectrum chemical that acts instantly.
(B) It can be easily brewed in large liquid fermentation tanks overnight.
(C) It completely eradicates weeds along with nematodes.

(A) It is an effective parasite of root-knot and cyst nematode eggs.
(B) It can be mass-multiplied on cheap substrates like grain or agro-waste.
(C) It penetrates the eggshell using physical pressure and enzymatic action (chitinases/ proteases).
(D) It is highly sensitive to most chemical nematicides, completely ruling out any use in integrated management.

2023

227. What is the conceptual mechanism by which Mononchid nematodes hunt?
(A) They use a large buccal cavity armed with teeth to seize and swallow prey nematodes whole.
(B) They secrete an airborne toxin that paralyzes prey.
(C) They set up adhesive mycelial nets in the soil.
(D) They inject eggs into the bodies of living root-knot nematodes.

2011

228. In a cause-and-effect relationship, how does a high soil moisture content (near field capacity) affect the efficacy of a volatile fumigant like 1,3-Dichloropropene?
(A) It drastically improves efficacy by allowing the gas to dissolve perfectly.
(B) It causes the fumigant to instantly ignite.
(C) It restricts the diffusion of the fumigant gas through the soil pore spaces, leading to poor distribution and reduced efficacy.
(D) It has absolutely no effect on fumigant movement.

2004

229. How are constitutive biochemical resistance factors, such as pre-existing toxins in roots, classified in the context of host plant resistance?
(A) They can act as pre-infectional biochemical factors if they contain constitutive nematoxic or repellent compounds.
(B) As strictly post-infectional biochemical defenses.
(C) As physical structural barriers.
(D) As acquired systemic immune signals.

2008

230. Consider the following statements about resistance genetics:
I. The Mi gene in tomato provides resistance against Meloidogyne incognita, M. javanica, and M. arenaria.
II. The H1 gene in potato confers resistance to Globodera rostochiensis.
III. Resistance conferred by the Mi gene is stable at all temperature extremes, including above 35°C.
IV. The Mi gene is a single dominant gene.
V. Globodera pallida is effectively controlled by the H1 gene.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III and IV
(D) I, II and V

2023

231. Which feature is most relevant for identifying a successful outcome of Integrated Nematode Management (INM)?
(A) Total, 100% eradication of every single nematode in the field.
(B) Maintaining the population below ETL while maximizing net economic returns.
(C) The complete replacement of all chemical fertilizers with green manure.
(D) The visible death of all soil micro-arthropods.

2011

232. What can be inferred if a farmer continuously uses the exact same non-fumigant nematicide (e.g., Carbofuran) in the same field for 10 years?
(A) The field will become completely permanently sterile.
(B) The chemical will accumulate until it spontaneously transforms into a fumigant.
(C) Successive use may cause enhanced microbial degradation which reduces field efficacy.
(D) The nematodes will mutate into a beneficial, nitrogen-fixing species.

2010

233. Which definition best characterizes "Pest Risk Analysis" (PRA)?
(A) A purely financial audit of a farm's pesticide budget.
(B) The physical counting of all insects crossing a national border.
(C) The method of mixing different chemicals in a spray tank.
(D) Evaluation of scientific evidence to determine if a pest should be regulated and measures taken.

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(B) High C:N ratio materials release ammonia instantly, while low C:N materials immobilize nitrogen.
(C) The C:N ratio dictates whether the amendment will become a fungus or a bacterium.
(D) Amendments with a C:N ratio of 0 are the only effective nematicides.

2004

219. Which feature is most relevant to the design of a Combination (multiplex) RNAi strategy against nematodes?
(A) Targeting only a single non-essential gene.
(B) Using single constructs to target multiple essential genes to increase efficacy and reduce resistance.
(C) Mixing RNAi with high doses of organophosphates.
(D) Using RNAi only on the leaves of the plant.

2016

220. Consider the following statements regarding nematode effectors:
I. Effectors are exclusively secreted by the nematode's cuticle.
II. The subventral glands primarily secrete cell-wall degrading enzymes during migration.
III. The dorsal gland secretes effectors necessary for maintaining the feeding site.
IV. Effectors can suppress the host's innate immune system (PAMP-triggered immunity).
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) I only
(C) III and IV
(D) I, II and IV

2008

221. What can be inferred from the discovery that some nematode effectors closely resemble plant regulatory proteins (e.g., CLAVATA3-like peptides)?
(A) Nematodes have evolved to secrete structural mimics of plant peptides to hijack host pathways.
(B) Nematodes are anatomically identical to plants.
(C) The sequencing was flawed and contaminated with plant DNA.
(D) The plant actively donated these genes to the nematode to help it survive.

2019

222. Which definition applies to "proteinase inhibitors" (PIs) engineered into transgenic plants?
(A) Proteins that degrade the plant's own cell wall.
(B) Small RNAs that silence nematode genes.
(C) Anti-nutritional proteins that inhibit gut proteases to impair digestion and cause stunting.
(D) Chemicals that fumigate the soil around the root.

2004

223. Which of the following factors primarily led to the restriction or banning of DBCP (1,2-dibromo-3-chloropropane)?
(A) It was totally ineffective against root-knot nematodes.
(B) It was heavily depleting the ozone layer.
(C) It caused immediate death of established perennial orchards upon application.
(D) It caused severe groundwater contamination and was linked to male worker sterility.

2022

224. Which of the following is a factual statement regarding how the mode of action of organophosphates and carbamates differs in terms of reversibility?
(A) Carbamate binding is irreversible, whereas organophosphate binding is reversible.
(B) Both are strictly physical barriers and do not bind to enzymes.
(C) Organophosphate binding to AChE is generally considered irreversible, whereas carbamate binding is often reversible.
(D) Both cause instant irreversible cuticle shedding.

NODIA

2014

225. Identify the correct statement regarding Fluopyram.
(A) It acts by inhibiting the enzyme acetylcholinesterase.
(B) It is a succinate dehydrogenase inhibitor (SDHI) that disrupts mitochondrial respiration in nematodes.
(C) It is a botanical extract derived from marigolds.
(D) It is an old, classical fumigant gas banned by the Montreal Protocol.

2024

226. Which statement INCORRECTLY describes Purpureocillium lilacinum?

that never degrade.
(C) They are perfectly uniform in their chemical composition and efficacy.
(D) They improve soil properties and stimulate beneficial antagonistic microbes for suppression.

2022

243. Which feature is most relevant to the action of Arthrobotrys species as biocontrol agents?
(A) They produce specialized three-dimensional adhesive nets or constricting rings to physically trap and consume motile nematodes.
(B) They form obligate symbiotic relationships with the plant roots, similar to mycorrhizae.
(C) They act purely as a bio-fumigant, releasing hydrogen cyanide gas.
(D) They parasitize the stationary female root-knot nematode exclusively.

2003

244. What can be inferred about the widespread adoption of predatory nematodes (like Mononchids) in commercial agriculture?
(A) It is currently the most popular and dominant form of nematode control globally.
(B) They have completely replaced the need for all chemical nematicides.
(C) Challenges in mass rearing, formulation, and cannibalism limit commercial field application.
(D) They are easily applied as a foliar spray to control endoparasites.

2024

245. Which definition correctly outlines the purpose of international phytosanitary certification?
(A) An official NPPO document verifying a shipment conforms to specific importing requirements.
(B) To guarantee the crop was grown using 100% organic methods.
(C) To set the international market price for agricultural goods.
(D) To ensure the seeds have high germination vigor.

2023

246. In which region of India is domestic quarantine strictly enforced for the Potato Cyst Nematode?
(A) The Indo-Gangetic Plains of Punjab
(B) The desert regions of Rajasthan
(C) The coastal plains of Kerala
(D) The Nilgiri and Kodaikanal hills of Tamil Nadu

2024

247. Which of the following is a factual statement regarding how the chemical 1,3-Dichloropropene is applied?
(A) It is applied primarily as a foliar systemic spray.
(B) It is applied primarily as a pre-plant soil fumigant via shank injection.
(C) It is applied primarily as a dry powder dusted onto leaves.
(D) It is applied primarily as a granular side-dress on mature trees.

2013

248. Identify the correct statement regarding the mechanism of AChE inhibiting nematicides.
(A) They permanently dissolve the chitin in the nematode eggshell.
(B) They block the electron transport chain in the mitochondria.
(C) They disrupt the transmission of nerve impulses across the synapse by preventing the breakdown of the neurotransmitter acetylcholine.
(D) They inhibit the synthesis of sterols in the nematode gut.

2011

249. Which statement INCORRECTLY details the properties of next-generation nematicides like Fluensulfone?
(A) They represent a novel class of chemistry compared to old OPs and carbamates.
(B) They generally have a much more favorable environmental and mammalian toxicity profile.
(C) They cause cessation of feeding, locomotion, and development in target nematodes.
(D) They act as powerful, broad-spectrum soil fumigants that sterilize the field.

2001

250. Match the resistance gene in List I with its corresponding nematode/crop system in List II.
List I: (Gene)
P. Mi-1.2
Q. H1
R. Hs1pro-1
S. Rk
List II: (System)
1. Potato Cyst Nematode (G. rostochiensis) in Potato
2. Root-knot nematode in Tomato

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2005

234. What is the primary reason for using the "W-pattern" in nematode sampling?
(A) Representative coverage to account for the aggregated distribution of nematodes.
(B) It is used to trace the underground flight path of adult nematodes.
(C) It is the specific shape required for plowing to kill cyst nematodes.
(D) It refers to the chemical structure of organophosphates.

2001

235. Which of the following is a factual statement regarding soil sampling for nematode assay?
(A) One should avoid sampling from the active root zone.
(B) One should avoid sampling severely desiccated, dead plants or leaving samples in a hot vehicle.
(C) One should avoid taking a mixture of soil and fine feeder roots.
(D) One should avoid using a soil auger or trowel.

2006

236. Identify the correct statement regarding Economic Threshold Levels (ETL).
(A) ETL is a fixed, universal number for a specific nematode species, regardless of the crop or environment.
(B) ETL fluctuates based on the market value, cost of intervention, and environment.
(C) ETL is always calculated after the crop has been fully harvested.
(D) ETL calculation strictly ignores the natural enemy population in the soil.

2014

237. Which statement INCORRECTLY characterizes the use of solarization?
(A) The soil must be completely dry and powder-like for the heat to penetrate deeply.
(B) It works best during the hot summer months with clear skies.
(C) A thin, transparent polyethylene film is more effective at trapping heat than thick black film.
(D) It can provide additional benefits like controlling soil-borne fungal pathogens and weed seeds.

2003

238. What is the conceptual framework of using hot water treatment for planting material?
(A) To physically wash off dirt from the roots before sale.
(B) To boil the roots until they are completely sterilized and dead.
(C) To exploit the thermal tolerance differential between the plant tissue and the nematode.
(D) To induce the plant to produce massive amounts of phytoalexins.

NODIA

2006

239. In a cause-and-effect context, how does flooding a paddy field control root-knot nematodes?
(A) It drowns them by filling their lungs with water.
(B) It causes the nematodes to rapidly swim to the surface where they are eaten by birds.
(C) It washes the nematodes completely out of the field into the ocean.
(D) It leads to anaerobiosis and the accumulation of lethal substances like hydrogen sulfide.

2009

240. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Crop rotation is highly effective for managing nematodes with narrow host ranges, such as the potato cyst nematode.
Reason (R): Growing a non-host crop deprives the obligate endoparasitic nematode of a food source, leading to starvation and a progressive decline in soil population density.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

241. How are crops like marigold (Tagetes spp.) functionally classified in an INM module?
(A) As highly susceptible catch crops.
(B) As antagonistic crops that reduce populations through nematicidal allelochemical exudation.
(C) As simple physical barriers.
(D) As primary cash crops yielding high-value grain.

2011

242. Comparing organic amendments to chemical fumigants, what is a distinct ecological advantage of organic amendments?
(A) They act much faster and kill a wider spectrum of soil life.
(B) They are highly persistent toxic chemicals

2008

259. Which of the following is a factual statement regarding how Meloidogyne interacts with a susceptible plant?
(A) It induces the formation of multinucleate giant cells via repeated mitosis without cytokinesis.
(B) It induces the formation of syncytia via cell wall dissolution.
(C) It induces the formation of solid wooden galls devoid of any living cells.
(D) It induces the formation of normal healthy root hairs.

2005

260. Arrange the following steps for generating a transgenic plant with nematode resistance via HIGS in the correct sequence:
I. Identify essential nematode target gene
II. Synthesize dsRNA construct homologous to the target gene
III. Transform the construct into the host plant genome
IV. Express the construct in feeding sites
(A) I, II, III, IV
(B) II, III, IV, I
(C) I, II, IV, III
(D) III, IV, I, II

2003

261. Identify the correct statement regarding plant proteinase inhibitors (PIs) in transgenic resistance.
(A) Ingested PIs interfere with gut enzymes causing amino acid deficiency and stunting.
(B) PIs enhance the nutritional quality of the plant for the nematode.
(C) PIs strictly target and destroy the nematode's reproductive organs physically.
(D) PIs are highly volatile and fumigate the soil around the transgenic roots.

2025

262. Which statement INCORRECTLY characterizes the use of Bacillus thuringiensis (Bt) against plant-parasitic nematodes?
(A) Nematicidal Cry proteins, such as Cry5B, have shown toxicity to several nematode species.
(B) Because many plant-parasitic nematodes have very narrow stylet orifices, ingestion of large intact Bt crystals in the soil is highly inefficient.
(C) Transgenic expression of Bt toxins directly inside the plant roots is a potential delivery method to bypass the stylet size restriction.
(D) Standard insecticidal Bt crops (like Bollgard cotton) automatically provide 100% control of all root-knot nematodes in the soil.

2015

263. What is the conceptual significance of sequencing the genome of Caenorhabditis elegans for plant nematology?
(A) It proved that all nematodes are exactly identical.
(B) Its well-annotated genome provides a blueprint for comparative and functional studies.
(C) It directly resulted in a chemical pesticide that wiped out C. elegans.
(D) It showed that C. elegans is the true ancestor of all plants.

2019

264. In a cause-and-effect relationship, how does horizontal gene transfer (HGT) influence the parasitome of phytoparasitic nematodes?
(A) It causes the nematodes to suddenly transform into bacteria.
(B) HGT causes the nematode genome to shrink until it disappears.
(C) Gene acquisition from microbes provided enzymes to degrade plant cell walls.
(D) It removes all resistance genes from the host plant.

2009

265. How are nematode esophageal gland effectors functionally classified based on transcriptomic analyses?
(A) They are synthesized exclusively in the nematode's tail and secreted through the anus.
(B) They are synthesized in the host plant's leaves and travel to the roots.
(C) They are synthesized in the nematode's cuticle and shed into the soil.
(D) Parasitism effectors are synthesized in esophageal glands and secreted via the stylet.

2011

266. Comparing the transcriptomes of pre-parasitic J2s and sedentary adult females of Meloidogyne, what major difference is generally observed?
(A) J2s express genes for locomotion and migration while adults focus on site maintenance.
(B) There is absolutely no difference in gene

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2001

283. Which of the following is a factual statement regarding taking a composite soil sample for nematode analysis?

(A) Individual soil cores should be kept entirely separate and sent to the lab in different bags.

(B) Individual soil cores should be thoroughly and gently mixed together to form a representative composite sample before drawing a subsample.

(C) Individual soil cores should be heated in an oven to dry them out before mixing.

(D) Individual soil cores should be washed with heavy bleach to remove soil bacteria before mailing.

2011

284. Identify the correct statement regarding the application of oil cakes for nematode management.

(A) They must be applied on the day of sowing to be maximally effective.

(B) A waiting period of 2 to 3 weeks after incorporation is essential to allow for microbial decomposition before planting.

(C) Oil cakes strictly act as fumigants and evaporate into the air.

(D) Neem cake has no effect on root-knot nematodes.

2022

285. Which statement INCORRECTLY outlines the use of biological control agents in nematology?

(A) Biological agents universally provide the exact same rapid, 100% knockdown effect as methyl bromide within 24 hours.

(B) Purpureocillium lilacinum is highly effective against root-knot nematode eggs.

(C) Pasteuria penetrans limits juvenile ability to successfully infect the root and reproduce.

(D) Biological agents often require specific soil temperature and moisture parameters to establish and thrive.

2013

286. What is the conceptual advantage of deploying a resistant variety over using synthetic nematicides?

(A) Resistant varieties are completely free and require no seed cost.

(B) Resistant varieties can permanently immunize the soil against all fungal pathogens as well.

(C) It is environmentally safe and provides season-long protection embedded in the seed.

(D) Resistant varieties always mature twice as fast as susceptible ones.

2016

287. In a cause-and-effect relationship, how does a specific antagonistic rhizobacterium like Bacillus firmus protect a plant?

(A) It secretes strong acidic compounds that dissolve the soil matrix.

(B) It forces the plant to undergo rapid, entire root system necrosis to starve the nematode.

(C) It travels into the plant leaves to perform photosynthesis.

(D) Biofilm colonization and metabolite secretion confuse host-finding and damage eggs.

2001

288. How is the host range of a nematode linked to the success of crop rotation?

(A) A highly polyphagous nematode with a wide host range is much easier to manage with rotation than a specialized one.

(B) Host range has absolutely no bearing on the success of crop rotation.

(C) Specialised pests like Globodera rostochiensis are easier to manage with rotation.

(D) All nematodes have the exact same host range globally.

2001

289. Comparing the modes of parasitism, how do Meloidogyne and Globodera differ in their feeding site formation?

(A) Meloidogyne causes cell wall breakdown to form a syncytium; Globodera causes repeated mitosis to form giant cells.

(B) Meloidogyne induces multinucleate giant cells while Globodera induces syncytia.

(C) Both form identical giant cells.

(D) Neither forms any specialized feeding structure.

NODIA

2012

290. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):

Assertion (A): The use of strict domestic quarantine in the Nilgiris has been implemented to restrict the movement of potato tubers.

Reason (R): Potato Cyst Nematodes (PCN) are highly mobile and can actively swim hundreds of kilometers through soil water to infest new geographic regions.

(D) Its endospores are environmentally resistant, allowing excellent long-term persistence.

2003

275. In a cause-and-effect relationship, what occurs when a nematode ingests a double-stranded RNA (dsRNA) molecule matching one of its essential genes?
(A) Silencing machinery processes dsRNA into siRNAs that degrade target endogenous mRNA.
(B) The nematode uses the dsRNA as a nutrient source to grow faster.
(C) The dsRNA directly attacks and breaks the nematode's DNA double helix.
(D) The nematode instantly mutates into a free-living species.

2023

276. How is the process of Pest Risk Analysis (PRA) structurally classified?
(A) As a purely arbitrary political decision.
(B) As a simple one-step chemical test performed at the border.
(C) As a science-based process involving Initiation, Risk Assessment, and Risk Management.
(D) As an entirely voluntary guideline for farmers.

2022

277. Comparing systemic non-fumigants to classic fumigants, what is a distinct application requirement for systemic non-fumigants?
(A) They require soil moisture to reach the soil solution and be absorbed by host roots.
(B) They must be deeply injected and sealed with a heavy plastic tarp.
(C) They must be applied as a pure, dry gas.
(D) They can only be applied to dead plant material.

2008

278. Which feature is most relevant to the efficacy of the Hs1pro-1 gene?
(A) It grants total immunity preventing any initial root invasion.
(B) It causes the sugarbeet to secrete lethal gas into the soil.
(C) It works by making the sugarbeet taproot physically harder than rock.
(D) Feeding site degradation leads to starvation, death, or an altered male-to-female ratio.

2002

279. What can be inferred about the future of INM with the advent of next-generation sequencing (NGS)?
(A) NGS will completely replace the need for crop rotation.
(B) Sequence data will help identify highly specific targets for precise bionematicides.
(C) NGS will make biological control obsolete.
(D) NGS proves that nematodes are entirely immune to all management strategies.

NODIA

2003

280. Arrange the typical steps involved in executing a Host-Induced Gene Silencing (HIGS) strategy for nematode control in the correct sequence:
I. Identification of an essential target gene in the nematode through transcriptomics
II. Synthesis of a hairpin dsRNA construct homologous to the target gene
III. Transformation of the construct into the host plant genome via Agrobacterium
IV. Ingestion of dsRNA by the nematode and subsequent target gene silencing
(A) I, II, III, IV
(B) I, III, II, IV
(C) III, I, II, IV
(D) II, III, I, IV

2010

281. Which definition accurately reflects the meaning of "synergism" within an Integrated Nematode Management (INM) context?
(A) Using two methods that completely cancel each other out.
(B) The process of rotating crops purely for soil fertility, ignoring nematodes.
(C) Applying the exact same chemical twice in one week.
(D) Combined use of compatible tactics where the effect is greater than their simple sum.

2023

282. What is the primary mechanism of action for Fluensulfone?
(A) It impairs mobility and development without inhibiting acetylcholinesterase.
(B) It generates highly reactive oxygen species (ROS) in the soil.
(C) It acts as a direct chitin synthesis inhibitor.
(D) It physically coats the nematode in an impermeable polymer.

3. Root-knot nematode in Cowpea
4. Sugarbeet cyst nematode in Sugarbeet

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

2021

251. What is the conceptual difference between a nematicide formulation designated as "EC" vs "GR"?
(A) EC means Entirely Chemical; GR means Generally Resistant.
(B) EC is a liquid concentrate for water-mixing while GR is a dry solid for direct soil application.
(C) EC is only for fumigants; GR is only for botanicals.
(D) There is no practical difference in how they are applied in the field.

2016

252. In an integrated management approach, why is chemigation through a drip system highly efficient for nematode control?
(A) It applies the chemical to the leaves, which then drips to the soil.
(B) It delivers the agent precisely to the active root zone where nematodes concentrate.
(C) It turns the irrigation water into a volatile gas that fumigates the air.
(D) It completely prevents weeds from germinating anywhere in the field.

2004

253. How does the presence of high levels of undecomposed organic matter in the soil affect the application of non-fumigant chemical nematicides?
(A) High organic matter adsorbs chemical agents, reducing their availability to contact nematodes.
(B) It greatly enhances their systemic uptake by the plant leaves.
(C) It causes the chemicals to instantly ignite.
(D) It has no effect whatsoever on chemical efficacy.

2014

254. Comparing pre-infectional to post-infectional host resistance, what role do phytoalexins play?
(A) They are structural barriers present before the nematode arrives.
(B) They are specific to the nematode cuticle and absent in plants.
(C) They are synthesized de novo by the plant only after the nematode attempts penetration or infection.
(D) They act as powerful long-distance attractants guiding the nematode.

2015

255. Which feature is most relevant to the successful deployment of the Mi gene in hot climates?
(A) It works perfectly up to 45°C.
(B) It requires heavy watering to maintain its resistance.
(C) It transforms the tomato plant into a completely different species under heat stress.
(D) Its resistance is sensitive to temperature and often breaks down above 28-30°C.

2009

256. What can be inferred about the role of RNA interference (RNAi) as a nematicide technology?
(A) It is a broad-spectrum chemical poison that acts like methyl bromide.
(B) It involves physically extracting the nematode's brain.
(C) It provides a targeted sequence-specific approach to silence genes without non-target harm.
(D) It is already the dominant, cheap method used by every smallholder farmer globally.

2003

257. Which definition correctly outlines the concept of Host-Induced Gene Silencing (HIGS)?
(A) Spraying small chemical molecules on a host plant to make it silent to the wind.
(B) Engineering host plants to express dsRNA that triggers gene silencing upon ingestion.
(C) Using hot water treatment to silence the genes of seeds.
(D) Silencing the host plant's own resistance genes so the nematode can feed peacefully.

2004

258. Which of the following accurately describes the origin of the Hs1pro-1 gene?
(A) It was synthetically created in a chemistry lab.
(B) It is a bacterial gene isolated from Bacillus thuringiensis.
(C) It is naturally found in all varieties of wheat.
(D) It was introgressed into cultivated sugarbeet from the wild relative Beta procumbens.

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(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

291. Which feature is most critically evaluated during a Pest Risk Analysis (PRA) for a specific plant-parasitic nematode?
(A) Potential establishment in local climates, economic impact, and entry pathways.
(B) Its ability to synthesize its own food through photosynthesis.
(C) Its precise morphological color under a light microscope.
(D) The historical name of the person who first discovered it.

2004

292. What can be inferred from the transition of the chemical control industry from fumigants to target-specific non-fumigants like Fluopyram?
(A) Fumigants were found to be completely ineffective at killing nematodes.
(B) Non-fumigants are significantly cheaper to manufacture than fumigants.
(C) Regulatory pressure and environmental safety forced the shift to targeted chemistries.
(D) Farmers preferred applying chemicals via heavy machinery rather than drip irrigation.

2001

293. Which definition best characterizes "chemigation" when applied to modern precision agriculture?
(A) Precise application of water-soluble nematicides directly through irrigation systems.
(B) The indiscriminate aerial spraying of broad-spectrum chemicals over an entire landscape.
(C) The process of genetically engineering a crop to produce chemicals.
(D) The mixing of dry granular chemicals directly into the seed hopper.

2001

294. Which of the following identifies the source of the biological nematicide Abamectin?
(A) Extracts from the seeds of the Neem tree (Azadirachta indica).
(B) Volatile gases emitted by crushed mustard roots.
(C) The physical spores of Purpureocillium lilacinum.
(D) Fermentation products of the soil bacterium Streptomyces avermitilis.

2006

295. Which of the following is a factual statement regarding the genetic architecture of plant resistance via the H1 gene?
(A) It exhibits polygenic, quantitative inheritance.
(B) It exhibits single dominant gene inheritance, conferring high-level resistance.
(C) It exhibits purely recessive inheritance, requiring both alleles to function.
(D) It exhibits maternal cytoplasmic inheritance only.

2015

296. Identify the correct statement regarding the integration of methods in INM.
(A) Applying organic amendments and planting a resistant variety represents antagonistic methods.
(B) Chemical fumigation strictly enhances the survival of all biological control agents.
(C) Solarization followed by bio-agent application often results in synergistic reduction.
(D) Deep summer ploughing completely negates any benefit of crop rotation.

2014

297. Which statement INCORRECTLY describes the mechanism of RNA interference (RNAi) as applied to nematode management?
(A) It involves the cleavage of double-stranded RNA into short interfering RNAs (siRNAs).
(B) The siRNAs guide the RNA-induced silencing complex (RISC) to degrade the matching target mRNA.
(C) HIGS allows the plant to act as the continuous delivery mechanism for the dsRNA trigger.
(D) RNAi permanently alters the fundamental genomic DNA sequence of the nematode.

2022

298. What is the conceptual advantage of whole-genome sequencing of phytoparasitic nematodes like Meloidogyne incognita?
(A) Systematically unveiling parasitism genes and pathways to accelerate target discovery.
(B) It provides a mere historical record of the species.
(C) It instantly grants the plant natural immunity to the nematode.
(D) It proves that chemical control is fundamentally impossible.

NODIA

out of the production and use of the chemical for most applications.

61. (A) It phased out the production and use of methyl bromide due to its ozone-depleting properties.
The Montreal Protocol is an international treaty designed to protect the ozone layer by phasing out the production of various substances. In the context of nematode management, the protocol's most significant impact was the global restriction of methyl bromide. This decision forced the agricultural industry to search for alternative management strategies, including new chemical fumigants, non-volatile nematicides, and various biological or cultural methods.

62. (C) DD mixture was highly specific, killing only nematodes while preserving all soil fungi and bacteria.
Early soil fumigants like the DD mixture were generally not specific in their action. While they were primarily used for nematode control, they also affected a wide range of other soil organisms, including many beneficial fungi and bacteria. This broad-spectrum activity often created a biological vacuum in the soil, which is a significant characteristic that distinguishes fumigants from more targeted modern nematicides.

63. (D) High vapor pressure is required for the chemical to volatilize and move effectively through soil air spaces.
Vapor pressure is a fundamental physical property that determines the movement and efficacy of soil fumigants. A high vapor pressure is necessary for the liquid chemical to rapidly convert into a gas upon application to the soil. This gaseous state allows the fumigant to diffuse through the network of soil pores, ensuring it reaches the target nematodes located throughout the treated soil volume.

64. (C) It breaks down in moist soil to generate methyl isothiocyanate (MITC), a highly toxic gas.
Metam sodium is a versatile soil fumigant that acts as a precursor to a toxic gas. When applied to moist soil, the compound undergoes a chemical reaction to release methyl isothiocyanate. This volatile byproduct is the primary active agent that eliminates nematodes, fungi, and weeds. The effectiveness of the treatment depends on the rapid conversion and even distribution of MITC throughout the soil profile.

65. (B) 1,3-D is a fumigant that moves as a gas, whereas organophosphates are non-fumigants moving in soil water.
1,3-Dichloropropene and organophosphates represent two different classes of nematicides with distinct modes of action and movement. 1,3-D is a volatile fumigant that diffuses through the soil as a gas. In contrast, organophosphates are non-volatile chemicals that must dissolve in soil water and move through the liquid phase to come into contact with nematodes or be absorbed by plant roots.

66. (D) To trap the toxic gas in the soil profile long enough to achieve a lethal concentration-time (CT) product.
Sealing the soil surface after the application of a volatile fumigant like 1,3-D is essential for maximizing its efficacy. By using plastic tarps or a water seal, the escape of the gas into the atmosphere is significantly reduced. This ensures that the toxic vapors remain in the soil at a sufficient concentration for the time required to kill the target nematode population.

67. (A) DBCP, which could historically be used on living fruit tree roots.
Most early soil fumigants were highly phytotoxic and could only be used as pre-plant treatments to avoid killing the crop. DBCP was a notable exception to this rule, as it could be applied to established perennial crops, such as citrus and fruit orchards, without causing significant harm to the trees. This unique property made it an extremely valuable tool for managing nematodes in existing plantations.

68. (C) They bind to and reversibly inhibit the enzyme acetylcholinesterase at neuronal synapses.
Carbamate nematicides function by disrupting the nervous system of the target pests. They work by binding to the enzyme acetylcholinesterase, which is responsible for breaking down the neurotransmitter acetylcholine in the synaptic cleft. By inhibiting this enzyme, carbamates cause a buildup of acetylcholine, leading to continuous nerve firing, paralysis, and eventual death or starvation of the nematodes through the disruption of coordinated movement.

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ANSWERS

1. (B) The density where management must be initiated to prevent reaching the Injury Level.
The fundamental principle behind the Economic Threshold Level involves identifying the specific population density at which management actions must be implemented. This proactive approach aims to prevent the nematode population from increasing further and reaching the Economic Injury Level. Intervention at this stage ensures that the cost of control remains lower than the potential financial loss.

2. (D) Stratified zigzag or 'W' sampling pattern.
Effective estimation of nematode populations requires a sampling strategy that accounts for their aggregated or patchy distribution within the field. A stratified zigzag or 'W' pattern is considered statistically reliable as it covers the area more comprehensively than straight transects. This method provides a representative composite sample, which is essential for making accurate and informed management decisions.

3. (A) The damage coefficient
Within the mathematical framework of economic injury levels, the damage coefficient serves as a critical parameter. It represents the specific amount of yield loss attributed to each individual nematode present in the system. Accurate determination of this coefficient allows researchers and farmers to quantify the potential impact of varying population densities on the final productivity of the crop.

4. (C) ETL is always a numerically lower population density than EIL.
The Economic Threshold Level and the Economic Injury Level are distinct but related concepts in pest management. The threshold level is strategically set at a lower population density than the injury level to provide a safety margin. This ensures that control measures can be applied in time to suppress the population before it causes damage exceeding the treatment cost.

5. (A) A single five-kilogram composite sample from ten hectares provides minimal variance.
Statistical reliability in nematode sampling is highly dependent on the number of cores and the area covered. A single composite sample from a large area like ten hectares is insufficient because it fails to account for the naturally uneven distribution of nematodes. Increasing the number of samples reduces variance and provides a more accurate estimation of the actual population.

6. (D) The ETL is lowered because the crop's financial value justifies an earlier intervention.
Market dynamics significantly influence management thresholds. When a high-value cash crop is at risk, even a small reduction in yield results in a substantial financial loss. Consequently, the Economic Threshold Level is lowered, meaning that intervention is justified at lower nematode densities because the cost of treatment is small relative to the high value of the protected crop.

7. (B) Denaturation of cellular proteins and enzymes due to high soil heat.
Soil solarization utilizes solar energy to increase the temperature of moist soil to levels that are lethal to many soil-borne pests. The primary cause of nematode mortality during this process is the physical denaturation of essential cellular proteins and enzymes. Exposure to these high temperatures disrupts vital metabolic processes, leading to the eventual death of various nematode life stages.

8. (C) Thin, transparent polyethylene films (25-50 μm)
The selection of plastic film is vital for the thermal efficiency of soil solarization. Thin, transparent polyethylene films are preferred because they effectively transmit short-wave solar radiation into the soil while trapping long-wave infrared radiation. This greenhouse effect maximizes heat accumulation in the upper soil layers, creating a lethal environment for nematodes, weeds, and other soil-borne plant pathogens.

NODIA

9. (D) It frequently induces a positive growth response by increasing soluble nutrients.
Soil solarization offers unique benefits beyond pest suppression, including an observed increase in plant growth. The heat generated during the process accelerates the breakdown of organic matter, leading to the release of soluble nutrients like nitrogen, calcium, and magnesium. This increased nutrient availability often results in more vigorous plant development compared to treatments using traditional chemical soil fumigants.

10. (A) I and III
Solarization principles rely on using transparent plastic to maximize heat trapping through the greenhouse effect. This method is particularly effective in the upper soil profile, typically within the top 10 to 15 centimeters, where temperatures reach their peak. While it impacts deeper layers, the most significant reduction in nematode populations and weed seeds occurs near the soil surface.

11. (B) Providing adequate soil moisture before tarping to sensitize nematodes to heat.
Soil moisture is a critical factor for successful solarization because it increases the heat sensitivity of nematodes. Moist conditions stimulate the metabolic activity of dormant stages, making them more vulnerable to thermal damage. Additionally, water improves the thermal conductivity of the soil, ensuring that the solar heat is distributed more evenly and reaches deeper into the soil profile.

12. (B) The temperature and duration must be strictly controlled to prevent phytotoxicity.
Hot water treatment is a physical method used to disinfest planting materials like bulbs, corms, and tubers. Success depends on the narrow margin between the thermal death point of the nematode and the heat tolerance of the plant tissue. Precise control of both temperature and exposure time is mandatory to ensure the pests are eliminated without causing permanent damage.

13. (A) Using clean, certified material and hygienic practices to prevent pest introduction.
Phytosanitation involves a set of proactive measures designed to prevent the introduction and spread of plant pests. This includes the use of certified, nematode-free seeds or vegetative planting materials and maintaining strict hygiene in nurseries and fields. By excluding pathogens from the production system, farmers can avoid the significant yield losses and management costs associated with established nematode infestations.

14. (B) 44.5 °C for 3 to 4 hours
Managing the stem and bulb nematode in narcissus bulbs requires specific hot water treatment parameters to ensure efficacy. Immersing the bulbs at a temperature of 44.5 degrees Celsius for a duration of 3 to 4 hours effectively eliminates the nematodes. This long-duration treatment allows the heat to penetrate deep into the bulb tissues where the various life stages reside.

15. (D) Treatment is typically done at 55 °C for 20 minutes.
Hot water immersion is a standard practice for managing the burrowing nematode in banana planting material. Immersing the suckers at 55 degrees Celsius for 20 minutes is effective for reducing the nematode population within the corm tissues. This treatment is often combined with peeling the corm to remove necrotic lesions, further improving the overall health of the seedlings.

16. (B) It aims to expose deep-dwelling nematode life stages to solar desiccation and predators.
Deep summer ploughing is a traditional cultural practice that utilizes environmental factors to manage soil-borne pests. By turning the soil during the hottest months, nematodes and their eggs are brought to the surface. This exposure leads to their death through desiccation by dry winds and intense solar radiation, while also making them more accessible to various natural predators.

17. (B) Flooding for 2 to 3 days is generally sufficient to eradicate root-knot nematodes.
While flooding is an effective management tactic, it requires a significant duration to achieve substantial nematode reduction. Brief periods of submergence, such as two to three days, are generally insufficient to kill the pests. Effective control typically requires several weeks or even months of continuous flooding to create the anaerobic conditions and toxic byproducts necessary for significant population decline.

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18. (D) It physically removes the water film required for nematode respiration and movement.
Nematodes are aquatic organisms that require a thin film of water surrounding soil particles for their survival and activities. Prolonged soil drying or desiccation removes this essential moisture, physically preventing the nematodes from moving and finding host roots. Furthermore, the lack of water disrupts their respiratory processes and can lead to lethal dehydration of their delicate, permeable cuticles.

19. (A) Removing host plants forces obligate plant-parasitic nematodes into starvation and population decline.
Fallowing is a cultural management strategy that involves leaving a field uncultivated for a specific period. Since plant-parasitic nematodes are obligate parasites, they require a living host to feed and reproduce. By removing all host plants and controlling weeds, the nematodes are deprived of nutrition, eventually leading to a natural decline in their population through starvation and environmental stress.

20. (B) I and III
Cultural methods like fallowing and deep ploughing have specific limitations and requirements. Fallowing is often economically challenging for small-holder farmers because it results in a total loss of income from that land for a season. Additionally, maintaining a clean, weed-free fallow is essential because many common weed species can serve as alternate hosts for plant-parasitic nematodes.

21. (A) Classification based on susceptibility into highly susceptible, tolerant, and non-host crops.
Design of an effective crop rotation for root-knot nematode management relies on understanding the host status of different crops. Plants are typically classified as highly susceptible, tolerant, or non-hosts based on their ability to support nematode reproduction and their reaction to damage. Including non-host or resistant crops in the rotation sequence is the primary mechanism used to reduce soil populations.

22. (D) Trap crops are destroyed before reproduction, while antagonistic plants actively repel or kill pests.
Trap crops and antagonistic plants utilize different biological mechanisms to manage nematode populations. A trap crop is a susceptible host that is planted to attract nematodes but is then destroyed before the pests can complete their life cycle. In contrast, antagonistic plants like marigold produce chemical compounds that are toxic to nematodes or act as poor hosts that prevent reproduction.

23. (B) When the non-host crop is heavily infested with susceptible weed species.
The effectiveness of using non-host crops to reduce nematode populations can be compromised by poor weed management. If the field contains susceptible weed species, the nematodes can continue to feed and reproduce on those weeds even while a non-host crop is being grown. This highlights the importance of maintaining clean cultivation to ensure the success of any rotation-based management strategy.

24. (C) Alpha-terthienyl
Marigolds are well-known for their antagonistic properties against various plant-parasitic nematodes. The roots of these plants synthesize and release a potent nematicidal compound called alpha-terthienyl. This bioactive molecule disrupts the physiology of nematodes in the rhizosphere, effectively reducing their population. This natural chemical defense makes marigold a valuable component in integrated nematode management systems and sustainable agricultural practices.

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25. (D) A susceptible crop used to stimulate infection and then destroyed before nematode reproduction.
A catch crop is a strategic management tool where a susceptible host is grown for a very short period. The objective is to stimulate the hatching of nematode eggs and the subsequent infection of the roots. Before the nematodes can reach maturity and produce the next generation of eggs, the crop is physically destroyed, effectively trapping and eliminating a portion of the population.

26. (A) Decomposition products like ammonia and volatile fatty acids released by microbial activity.
The suppression of nematodes by oil cakes is primarily a result of the chemical changes that occur during their decomposition in the soil. Microbial activity breaks down these organic materials, releasing various toxic byproducts such as ammonia and volatile fatty acids. These compounds act as natural nematicides,

2004

299. In a cause-and-effect relationship, how does the deployment of a transgenic crop expressing an effective plant proteinase inhibitor (PI) impact a sedentary endoparasitic nematode?

(A) The nematode rapidly dissolves the PI and uses it as an energy source.

(B) PI-enzyme binding impairs protein digestion, causing starvation and stunting.

(C) The PI acts as a highly attractive chemical, pulling nematodes into the root.

(D) The PI physically seals the nematode's stylet closed before it can penetrate the root.

2018

300. Which nematode species is the primary causal agent of the 'Molya' disease affecting wheat and barley crops in India?

(A) Anguina tritici

(B) Heterodera avenae

(C) Meloidogyne graminicola

(D) Pratylenchus thornei

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35. (A) Parasitizing the eggs and sedentary females of root-knot and cyst nematodes.
Purpureocillium lilacinum is a highly effective biological control agent widely used against various sedentary plant-parasitic nematodes. This fungus primarily targets the eggs and the sedentary female stages that remain within the root or in egg masses. By producing enzymes like chitinases and proteases, it penetrates the protective eggshells and the nematode cuticle, leading to the destruction of the developing embryos.

36. (C) It utilizes chlamydospores for long-term survival in the soil and infects nematode eggs.
Pochonia chlamydosporia is a specialized fungal parasite known for its ability to attack the eggs of cyst and root-knot nematodes. It produces thick-walled survival structures called chlamydospores, which allow the fungus to persist in the soil even in the absence of a host. When nematode egg masses are present, the fungus infects them, providing a consistent level of biological suppression.

37. (A) They rely entirely on zoospores to swim and locate nematode hosts.
Fungi in the genus Arthrobotrys are primarily known for their predacious behavior using specialized trapping organs rather than swimming zoospores. They develop adhesive networks or rings that are often induced by the presence of nematodes. These fungi are common in soil and play a vital role in natural nematode suppression by physically capturing and digesting various motile nematode species.

38. (D) Attaching endospores to juveniles which germinate and sterilize the developing female.
Pasteuria penetrans is a unique, obligate bacterial parasite that specifically targets root-knot nematodes. The infection begins when endospores in the soil attach to the cuticle of second-stage juveniles. As the nematode develops inside the plant root, the bacterium multiplies, eventually filling the entire body of the female. This process prevents the nematode from producing eggs, effectively sterilizing the individual and reducing the population.

39. (B) They alter root exudates and produce metabolites to reduce root penetration.
Antagonistic rhizobacteria, such as certain species of Pseudomonas, protect plants through indirect and direct mechanisms. When applied to seeds, they colonize the developing rhizosphere and can alter the chemical signals or exudates produced by the roots. Additionally, they produce various secondary metabolites that can repel nematodes or interfere with their ability to locate and penetrate the host tissues.

40. (C) A is true but R is false.
Pasteuria penetrans is an obligate parasite, meaning it requires a living nematode host to grow and reproduce. Because of this specialized biology, it cannot be cultured on standard laboratory media like Potato Dextrose Agar. While it is a highly effective biological control agent, the difficulty in mass-producing it without using live nematodes remains a significant challenge for its widespread commercial application.

41. (D) As bionematicides
Beneficial bacteria like Bacillus firmus are increasingly being utilized as commercial biological control products. These formulations are classified as bionematicides because they utilize living microorganisms or their natural products to manage nematode populations. They offer a sustainable alternative to synthetic chemicals, working through various mechanisms such as producing toxic metabolites, inducing systemic resistance in the host, or directly parasitizing nematode life stages.

42. (A) P. lilacinum targets eggs, while A. oligospora targets motile juveniles.
Different biological control agents target specific stages of the nematode life cycle. Purpureocillium lilacinum is primarily an egg parasite, focusing its activity on the sedentary stages and the protective egg masses. In contrast, Arthrobotrys oligospora is a predatory fungus that develops specialized traps to capture and digest the motile, infective juveniles that move through the soil in search of host roots.

43. (B) A heavily sclerotized, barrel-shaped buccal cavity often armed with a large mural tooth.
Predatory nematodes in the order Mononchida are characterized by their specialized feeding apparatus. They possess a robust, barrel-shaped buccal cavity with thick, sclerotized walls, which often contains one or more large mural teeth. This structure allows them to firmly seize other soil microorganisms, including smaller nematodes,

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significantly reducing the population of plant-parasitic nematodes while also providing nutrients to the soil.

27. (B) It encourages the proliferation of nematophagous fungi and releases toxic decomposition products.
Incorporating green manure into the soil provides a dual benefit for nematode management. The decomposition of the biomass releases organic acids and other chemicals that are directly toxic to nematodes. Furthermore, the addition of organic matter stimulates the activity of various soil microorganisms, including nematophagous fungi and predatory bacteria, which naturally suppress the populations of plant-parasitic nematodes over time.

28. (B) High levels of ammonia released during the decomposition of nitrogen-rich amendments are highly toxic to nematodes.
Ammonia is one of the most significant nematicidal byproducts generated during the breakdown of nitrogen-rich organic amendments like oil cakes and animal manures. When these materials decompose, they release ammonia gas into the soil pores, which is highly toxic to various life stages of nematodes. This chemical action is a major factor contributing to the effectiveness of organic soil amendments.

29. (A) Phenolics are the sole compounds responsible for the efficacy of neem cake.
While phenolic compounds contribute to the nematicidal properties of many organic amendments, they are not the only active ingredients. Neem cake, for instance, contains a complex mixture of bioactive limonoids such as azadirachtin, salannin, and nimbin. These multiple compounds work together to provide broad-spectrum suppression of nematodes through various mechanisms, including direct toxicity, repellent effects, and disruption of their development.

30. (B) I, III and IV
Organic amendments manage nematode populations through several mechanisms. Neem cake utilizes active principles like azadirachtin, while the decomposition of diverse organic matter produces volatile fatty acids and other toxic byproducts. A critical requirement for these amendments is a sufficient decomposition period, which allows the microbial processes to release the necessary nematicidal compounds before the next crop is planted.

31. (D) The $C{:}N$ ratio and the prevailing soil environment.
The efficacy of organic amendments in suppressing nematodes depends heavily on their chemical composition and the soil conditions. The $C{:}N$ ratio is particularly important because it influences the rate of decomposition and the type of byproducts released. Prevailing soil factors such as moisture, temperature, and microbial activity also determine how effectively these amendments release their nematicidal properties in the field.

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32. (C) Immediate planting would expose seedlings to phytotoxic decomposition products and heat.
A waiting period is essential after incorporating green manure or other organic amendments because the initial stages of decomposition can be harmful to young plants. The process releases high concentrations of volatile fatty acids, ammonia, and other products that are phytotoxic. Additionally, the rapid microbial activity can generate heat. Waiting allows these levels to stabilize, ensuring a safe environment for seed germination.

33. (B) It captures motile nematodes using rings or nets.
Nematode-trapping fungi are a unique group of natural enemies that develop specialized physical structures to capture their prey. These fungi produce intricate mycelial formations such as adhesive nets, non-constricting rings, or constricting rings that physically seize motile nematodes in the soil. Once the nematode is trapped, the fungus penetrates its cuticle and digests the internal contents for nutrition.

34. (D) Drechmeria coniospora
Drechmeria coniospora is a well-studied endoparasitic fungus that specializes in infecting nematodes. Unlike trapping fungi that use nets, this species produces adhesive spores that attach to the nematode's cuticle. These spores germinate, penetrate the host's body, and develop an internal mycelium that eventually consumes the entire nematode. This type of fungal parasitism is a significant natural regulator of nematode populations.

containment measure. By restricting the movement of seed potatoes and soil from the infested Nilgiri region, the government aims to protect the vast potato-growing areas in the northern plains. Preventing the spread of these long-lived cysts is crucial for maintaining the productivity and economic viability of the national potato industry.

53. (A) Domestic quarantine restricts pest movement within a country, while international quarantine regulates cross-border movement.
Quarantine measures are classified based on the geographical boundaries they protect. Domestic quarantine involves regulations designed to prevent the spread of a pest from an infested area to a non-infested area within the same country. International quarantine, on the other hand, focuses on preventing the introduction of exotic pests from other nations through the regulation of international trade and travel.

54. (D) Quarantine aims at exclusion and containment, whereas chemical control aims at population reduction in an infested field.
Quarantine and chemical control serve different strategic roles in pest management. Quarantine is a preventive and regulatory approach focused on exclusion and containment to keep a pest out of an area entirely. In contrast, chemical control is a curative or management tactic used once a pest is already established in a field, aiming to reduce its population to manageable levels.

55. (B) Their cysts can remain viable in the soil for 10-20 years without a host, making eradication extremely difficult.
The extreme persistence of Potato Cyst Nematodes is the primary biological reason for their strict quarantine. The protective cyst stage allows the eggs to remain viable in the soil for up to two decades even in the absence of a host crop. This long-term survival makes the nematode nearly impossible to eradicate once established, necessitating rigorous measures to prevent its introduction.

56. (C) Quarantine enforcement may have had breaches, such as the unregulated movement of seed potatoes or soil on farm machinery.
The occurrence of quarantined pests in new areas often indicates gaps in the enforcement of regulations. For nematodes, common pathways for spread include the movement of infested seed tubers, contaminated soil adhering to farm equipment, or unregulated trade. Despite legal restrictions, these physical pathways can allow the pests to bypass quarantine barriers and establish themselves in previously clean agricultural regions.

57. (D) A volatile compound that turns into a gas and diffuses through soil pore spaces to kill nematodes.
A true soil fumigant is characterized by its high volatility and ability to move through the soil as a gas. When applied to the soil, these compounds evaporate and diffuse through the air-filled pore spaces. This gaseous movement allows the chemical to reach and eliminate nematodes throughout a large volume of soil, providing broad-spectrum control of various soil-borne pests and pathogens.

58. (A) DBCP (1,2-dibromo-3-chloropropane)
DBCP was once a widely used and effective nematicide, uniquely valued for its low phytotoxicity on many perennial crops. However, its use was severely restricted and eventually banned in many countries after it was linked to serious health and environmental issues. These included the discovery of male sterility among factory workers and the detection of the chemical as a persistent contaminant in groundwater.

59. (B) It was a mixture of 1,3-dichloropropene and 1,2-dichloropropane.
The DD mixture was one of the earliest and most successful soil fumigants used in agriculture. It consisted of two primary halogenated hydrocarbons: 1,3-dichloropropene and 1,2-dichloropropane. This combination provided effective control against a wide range of plant-parasitic nematodes. Its development marked a significant milestone in the history of chemical nematology, paving the way for the use of volatile soil treatments.

60. (A) I, II, III
The history of methyl bromide management follows a clear chronological progression. After decades of widespread global use as a highly effective broad-spectrum fumigant, scientific research discovered its significant role in the depletion of the stratospheric ozone layer. This discovery led to the international Montreal Protocol, which mandated a systematic phase-

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and either swallow them whole or puncture their cuticles to consume the internal contents.

44. (B) Their cannibalistic nature and sensitivity to environmental changes make commercial field application difficult.
Although Mononchid nematodes are effective natural predators, their large-scale use in commercial agriculture faces significant hurdles. These nematodes are often sensitive to environmental fluctuations and soil disturbances. Furthermore, their cannibalistic tendencies and slow reproductive rates compared to their prey make it difficult to mass-produce and maintain high population densities in the field, limiting their current role in active management programs.

45. (A) They are generalist predators that consume nematodes along with fungi and organic debris.
Soil micro-arthropods, such as Collembolans and certain species of mites, play a diverse role in the soil ecosystem. Many of these organisms are generalist predators that include nematodes as a portion of their diet. By feeding on various nematode stages, they contribute to the complex web of natural antagonists that help regulate the population densities of both beneficial and plant-parasitic nematodes.

46. (C) Diplogasterids
Diplogasterid nematodes represent a significant group of soil-dwelling organisms known for their predatory behavior. Many species in this group possess specialized mouthparts that allow them to feed on other nematodes, bacteria, and fungi. Their presence in the soil contributes to the natural biological suppression of plant-parasitic nematodes, making them important subjects of study in the field of soil ecology and biological control.

47. (C) 2003
India updated its legislative framework for plant protection by introducing the Plant Quarantine Order in 2003. This significant update was designed to align national regulations with international standards, particularly the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures. This order provides the legal basis for regulating the import of agricultural commodities to prevent the entry of exotic pests.

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48. (C) PRA assesses the probability of pest introduction and its potential economic impact to justify quarantine measures.
Pest Risk Analysis is a scientifically rigorous process used by national plant protection organizations to evaluate potential threats. It involves assessing the likelihood of a pest entering, establishing, and spreading within a new area, as well as the potential economic and environmental consequences. The results of a PRA provide the necessary technical justification for implementing specific quarantine regulations and import restrictions.

49. (B) It eliminates the need for any physical inspection at the port of entry.
An international phytosanitary certificate is a vital document in global trade, but it does not replace the need for border inspections. While the certificate indicates that the exporting country has inspected the consignment and found it to meet the required standards, the importing country's quarantine authorities still conduct physical inspections and sampling to ensure compliance and verify the absence of regulated pests.

50. (A) P-2, Q-3, R-4, S-1
The management of international plant health involves various organizations and regulations. The IPPC is the global treaty governing these activities, while NPPOs are the national services responsible for certification. In India, the PQO 2003 is the primary legislation for agricultural imports. PRA is the essential analytical process used by these entities to evaluate the potential threat levels of imported pests.

51. (A) Nilgiri Hills (Tamil Nadu)
In India, the Potato Cyst Nematode is subject to strict domestic quarantine regulations. These measures specifically restrict the movement of potato tubers from the Nilgiri Hills in Tamil Nadu to other parts of the country. This localized restriction is essential because the Nilgiris was the first region where these highly destructive pests were discovered, and they remain relatively confined there.

52. (C) To confine the highly destructive nematode to the localized areas of the Nilgiris and prevent spread to other major potato-growing regions.
The domestic quarantine for Potato Cyst Nematodes was established as a strategic

69. (A) Fenamiphos
Fenamiphos is a well-known example of an organophosphate nematicide. Unlike volatile fumigants, it is a non-fumigant chemical that is typically applied to the soil in liquid or granular form. It moves through the soil water and is absorbed by plant roots, providing systemic protection. It works by inhibiting acetylcholinesterase, leading to the paralysis and death of nematodes that come into contact with it.

70. (D) They paralyze pests to prevent root feeding.
Many non-fumigant nematicides are described as nematistats because their primary effect at field-applied doses is to paralyze the nematodes rather than kill them instantly. This paralysis interferes with the nematode's ability to locate, move toward, and penetrate host roots. While the nematodes may remain alive for a period, they are unable to feed or reproduce, effectively preventing crop damage and reducing future populations.

71. (B) They are readily absorbed by plant roots and translocated acropetally (upward) in the xylem to protect against foliar and root-feeding nematodes.
Systemic non-fumigant nematicides are designed to be absorbed by the roots and move within the plant's vascular system. They primarily exhibit acropetal movement, meaning they are translocated upward through the xylem along with water. This systemic action allows the chemical to provide protection to the entire plant against both root-feeding nematodes and those that might attack the stems or foliage.

72. (C) They are highly volatile and primarily move through the soil as a gas.
Organophosphate nematicides are characterized as non-volatile or low-volatility compounds. Unlike soil fumigants, they do not move through the soil as a gas. Instead, they are relatively soluble in water and move through the soil solution. Their primary mode of action is the inhibition of the nervous system, and their lack of volatility distinguishes them from the gaseous soil treatments used in agriculture.

73. (D) AChE inhibition leads to acetylcholine buildup and lethal tetany.
The enzyme acetylcholinesterase is vital for terminating nerve impulses by breaking down acetylcholine. If this enzyme is inhibited by chemicals like organophosphates or carbamates, acetylcholine accumulates in the synaptic gap. This results in the continuous and over-stimulation of the nerves and muscles, leading to a state of lethal tetany or spastic paralysis, which ultimately prevents the nematode from performing basic life functions.

74. (A) Paralyzed nematodes may recover and resume feeding as the chemical concentration drops below the effective threshold.
Non-fumigant nematicides often act reversibly, especially at lower concentrations. If heavy rainfall washes the chemical out of the root zone shortly after application, the concentration in the soil solution can drop rapidly. In such cases, nematodes that were previously paralyzed by the treatment may recover their mobility and ability to feed, potentially leading to a resurgence of the pest problem and reduced efficacy.

75. (B) Succinate dehydrogenase inhibitors (SDHI) affecting complex II of the mitochondrial respiratory chain
Fluopyram represents a next-generation class of nematicides that utilizes a novel biochemical mode of action. It belongs to the succinate dehydrogenase inhibitor group, which targets the mitochondrial respiratory chain. By specifically inhibiting the enzyme succinate dehydrogenase in complex II, the chemical disrupts cellular energy production in the nematode. This targeted approach provides effective control while generally offering a more favorable safety profile.

76. (B) It has a novel mode of action with a significantly lower toxicity profile to mammals and non-target organisms.
Fluensulfone is a modern nematicide that offers several advantages over traditional chemistries. It possesses a unique mode of action that is distinct from acetylcholinesterase inhibitors. One of its most significant benefits is its reduced toxicity to humans, mammals, and many beneficial non-target organisms. This makes it a safer alternative for farmers and a more environmentally sustainable option for integrated nematode management programs.

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without the subsequent division of the cell itself (cytokinesis).

126. (C) Meloidogyne lacks many metabolic pathways, reflecting its obligate parasitic lifestyle.
Comparative genomics shows that obligate parasites like Meloidogyne have smaller repertoires of certain metabolic genes compared to free-living nematodes like C. elegans. Over evolutionary time, parasitic nematodes have lost many genes for synthesizing essential nutrients that they can instead acquire directly from their host plants. This streamlining of the genome is a common feature among organisms that have specialized to live within a host.

127. (D) The target should be an essential enzyme that is divergent in non-target organisms.
Identifying an ideal molecular target for a new bionematicide requires balancing efficacy with safety. The target must be a gene or enzyme that is absolutely essential for the nematode's survival or development. To ensure environmental and human safety, this target should also be significantly different, or absent entirely, in non-target organisms such as the host plant, beneficial insects, soil microbes, and mammals.

128. (C) It involves repurposed ancestral genes and genes acquired via horizontal transfer.
The evolution of the nematode parasitome is a complex process involving multiple genetic mechanisms. Genomic and transcriptomic studies indicate that many parasitism genes were originally ancestral genes that were repurposed for new functions. In addition, horizontal gene transfer from soil-dwelling bacteria and fungi provided the nematodes with novel tools, such as cell wall-degrading enzymes, that were essential for their transition to a plant-parasitic lifestyle.

129. (B) A highly susceptible plant grown to attract nematodes, which is destroyed before the nematodes can complete their life cycle.
A trap crop is a clever cultural management tool used to reduce nematode populations. It involves planting a host that is very attractive to the target nematode. The pest is allowed to infect the roots, but the crop is then physically destroyed before the nematodes have a chance to mature and lay eggs. This effectively "traps" and eliminates a significant portion of the soil population.

130. (B) I, III, IV and V
Effective nematode management relies on a variety of cultural and biological strategies. Summer ploughing utilizes desiccation to kill pests, while crop rotation with non-hosts starves them. Plants like marigold provide chemical suppression through toxic exudates. When using trap crops, precise timing of their destruction is mandatory to ensure the nematodes are eliminated before they can reproduce and further infest the field.

131. (A) It was heavily depleting the Earth's stratospheric ozone layer.
Methyl bromide was once the most widely used soil fumigant globally due to its incredible efficacy against many pests. However, it was discovered to be a powerful ozone-depleting substance. When released into the atmosphere, it breaks down and releases bromine, which destroys ozone molecules. This significant environmental risk led to the international Montreal Protocol, which mandated the phase-out of its production and agricultural use.

132. (C) It is most appropriately used for transplanted crops such as tomato, brinjal, or fruit tree seedlings.
The bare-root dip is a specialized pre-plant treatment designed for crops that are started in nurseries and then moved to the field. By dipping the roots of transplants like tomato or fruit tree seedlings into a nematicidal solution, farmers can provide immediate protection during the critical establishment phase. This method is highly efficient as it treats only the plant material, reducing chemical use.

133. (A) The Mi gene was originally transferred to cultivated tomato from the wild species Solanum peruvianum.
The Mi gene is a classic example of utilizing wild genetic resources to improve crop resistance. It was successfully introgressed into the cultivated tomato, Solanum lycopersicum, from the wild relative Solanum peruvianum through interspecific crossing. This gene has provided farmers with a highly effective and environmentally friendly method for managing root-knot nematodes in tomato production for many decades.

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85. (A) It provides localized protection to the emerging radicle while drastically reducing the total amount of active ingredient applied per hectare.
Seed treatment is a highly efficient application method that places the nematicide exactly where it is needed most. By coating the seed, the chemical provides immediate protection to the emerging radicle and young roots during their most vulnerable stage. This localized approach significantly reduces the total amount of chemical required per unit area, minimizing environmental exposure and lowering costs for the farmer.

86. (D) Emulsifiable Concentrate
In pesticide formulation technology, the abbreviation EC stands for Emulsifiable Concentrate. This type of formulation consists of the active ingredient dissolved in an organic solvent along with an emulsifier. When the concentrate is added to water, it forms a stable emulsion, where tiny droplets of the oil-based pesticide are dispersed throughout the water, allowing for uniform application through spraying or irrigation systems.

87. (B) Applying through irrigation ensures uniform distribution in the root zone.
Chemigation, or specifically nemigation, is the process of applying nematicides through an irrigation system. This method is highly effective because the water acts as a carrier, delivering the chemical directly and uniformly into the soil profile where the roots and nematodes are concentrated. This ensures that the active ingredient reaches the target pests throughout the entire root zone, improving the consistency of control.

88. (C) Pre-plant localized chemical or biological treatment for transplants/seedlings.
The bare-root dip is a targeted application technique used primarily for transplanted crops. Before planting, the roots of the seedlings or cuttings are immersed in a solution containing a nematicide or a biological control agent for a specific period. This localized treatment ensures that the young plant is protected from nematode invasion immediately after transplanting, which is a critical period for crop establishment.

89. (D) Granules require soil incorporation while ECs are applied via water.
Granular and emulsifiable concentrate formulations are applied using different field techniques. Granules are typically spread on the soil surface and then mechanically incorporated into the soil or moved into the root zone by irrigation. EC formulations are liquid concentrates designed to be mixed with water and applied as a soil drench, foliar spray, or through irrigation systems, ensuring a different pattern of distribution.

90. (B) II and III
Application technologies like bare-root dips and chemigation are essential tools in nematode management. Root dips allow the plant to absorb protective agents before transplanting, while chemigation is highly compatible with modern drip systems, allowing for precise delivery to the rhizosphere. In contrast, seed treatments are most effective for protecting young annual seedlings rather than providing life-long protection for deep-rooted perennial trees.

91. (B) Thickened root endodermis and highly suberized root epidermal cell walls
Host plant resistance often involves physical structures that exist before the nematode attempts to infect the root. A thickened endodermis and the presence of suberin or lignin in the cell walls of the root epidermis act as formidable mechanical barriers. these structural features can prevent or significantly slow down the penetration and movement of the nematode's stylet, thereby reducing the success of the infection.

92. (B) The plant triggers localized, programmed cell death at the site of infection, starving the biotrophic nematode.
The hypersensitive response is a rapid and highly effective defense mechanism in plants. Upon recognizing the presence of a nematode, the plant induces localized, programmed cell death in the tissues immediately surrounding the infection site. Since plant-parasitic nematodes are biotrophic and require living cells for nutrition, this targeted necrosis effectively starves the pest and prevents it from establishing a permanent feeding site.

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93. (A) Low molecular weight antimicrobial compounds synthesized de novo by plants in response to infection.
Phytoalexins are a critical component of the plant's induced biochemical defense system. These are low molecular weight compounds with antimicrobial and nematicidal properties that are not present in healthy plants. Instead, they are synthesized rapidly and specifically at the site of infection in response to chemical signals from the nematode. Their accumulation helps to inhibit the growth, development, and reproduction of the invading pest.

94. (C) Mi-1.2 gene
The Mi-1.2 gene is one of the most famous and widely utilized resistance genes in agriculture. Found in many modern tomato cultivars, it provides effective resistance against several major species of root-knot nematodes, including Meloidogyne incognita, M. javanica, and M. arenaria. This single dominant gene triggers a hypersensitive response that prevents the nematodes from establishing the giant cells necessary for their development and reproduction.

95. (D) Globodera rostochiensis
In the management of the potato cyst nematode, the H1 gene is a vital genetic resource. Originally derived from the wild potato species Solanum tuberosum ssp. andigena, this gene confers high-level resistance specifically against the Ro1 and Ro4 pathotypes of Globodera rostochiensis. Its use in potato breeding programs has been instrumental in controlling this devastating pest in many regions where potatoes are a major crop.

96. (C) Its resistance breaks down at soil temperatures above 28°C.
Although the Mi gene is a powerful tool for nematode management, its effectiveness is significantly influenced by environmental conditions. One of its primary limitations is temperature sensitivity. When soil temperatures consistently exceed 28 to 30 degrees Celsius, the resistance mechanism fails to activate properly. In these high-temperature environments, even tomato varieties carrying the Mi gene can become susceptible to infection by root-knot nematodes.

97. (B) It provides resistance primarily through the production of thick waxy cuticles on leaves.
The Hs1pro-1 gene was a landmark discovery as it was the first nematode resistance gene to be successfully cloned. It provides resistance to the sugarbeet cyst nematode, Heterodera schachtii. The resistance is manifested in the roots, where it interferes with the nematode's ability to develop a functional feeding site. This gene does not relate to leaf characteristics like waxy cuticles, which are unrelated to cyst nematode defense.

98. (D) Combining multiple compatible tactics to keep populations below ETL.
Integrated Nematode Management is a holistic strategy that focuses on long-term sustainability rather than total eradication. It involves the careful integration of various compatible tactics, such as cultural practices, biological control, host plant resistance, and the judicious use of chemicals. The goal is to suppress nematode populations below the Economic Threshold Level while minimizing costs and reducing negative impacts on the environment.

99. (A) Using sub-lethal doses of a nematicide that weakens nematodes, making them more susceptible to infection by Pasteuria penetrans.
Synergism occurs in integrated management when the combined effect of two methods is greater than the sum of their individual parts. An excellent example is using a low, sub-lethal dose of a chemical nematicide to stress and weaken the nematodes. This increased vulnerability makes it easier for biological control agents, like the bacterium Pasteuria penetrans, to infect and eventually eliminate the target pest population.

100. (A) P-3, Q-1, R-2, S-4
Managing nematodes effectively requires tailoring strategies to specific crop and pest scenarios. Protected cultivation often uses soil solarization and bio-agents, while potato cyst nematodes in the Nilgiris are managed through quarantine and resistant varieties like Kufri Swarna. In citrus orchards, systemic chemicals via drip irrigation are common, and field crops like wheat often rely on crop rotation with non-host species.

101. (A) RNAi silences specific mRNA, while Bt produces a protein toxic to the nematode gut.
RNA interference and Bacillus thuringiensis toxins represent two different biotechnological approaches to nematode management. RNAi is a post-transcriptional gene silencing mechanism that uses double-stranded RNA to degrade specific messenger RNA, preventing the production of essential proteins. In contrast, Bt

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technology involves the expression of crystalline proteins that, when ingested, bind to the nematode's intestinal lining and cause lethal pore formation.

102. (D) HIGS engineers the host to produce dsRNA which the nematode ingests while feeding.
Host-Induced Gene Silencing is a specific application of RNA interference where the plant itself is genetically engineered to act as the delivery system. The transgenic host plant produces double-stranded RNA molecules that are homologous to essential nematode genes. When the nematode feeds on the plant tissues, it ingests these dsRNA molecules, which then trigger the RNAi machinery within the nematode's own cells to silence the target gene.

103. (B) The gene must be involved in survival and lack homology to non-target organisms.
Successful RNA interference depends on selecting an appropriate target gene within the nematode. To ensure high efficacy and environmental safety, the chosen gene must be essential for the nematode's survival, development, or reproduction. Furthermore, it should have a unique genetic sequence that lacks significant homology with genes in the host plant, humans, or other non-target organisms to prevent accidental off-target silencing.

104. (C) It offers a highly targeted approach that minimizes off-target environmental effects compared to broad-spectrum chemicals.
Host-Induced Gene Silencing represents a significant advancement in precision pest management. Unlike broad-spectrum chemical nematicides that can affect many soil organisms, HIGS is highly sequence-specific. By targeting genes that are unique to the pest nematode, this technology minimizes the risk to beneficial soil microbes, insects, and vertebrates. This high degree of specificity makes it a potentially more sustainable and environmentally friendly alternative for future agriculture.

105. (D) PIs bind to and inhibit digestive proteases, leading to amino acid starvation.
Transgenic plants expressing proteinase inhibitors utilize a sophisticated anti-nutritional defense strategy. These inhibitors are proteins that bind specifically to the digestive enzymes, such as proteases, in the nematode's gut. By blocking these enzymes, the nematode becomes unable to properly break down and absorb proteins from the plant tissue. This leads to severe amino acid starvation, which stunts the growth and reproduction of the parasite.

106. (A) Snowdrop lectin (GNA)
Lectins are carbohydrate-binding proteins that can interfere with various biological processes in pests. The snowdrop lectin, often abbreviated as GNA, has been extensively researched for its potential to control plant-parasitic nematodes. When expressed in transgenic plants, GNA can bind to the sensory organs or the intestinal lining of nematodes, disrupting their feeding behavior, orientation, and overall development, thus providing a level of resistance.

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107. (B) Nematode-specific Cry proteins (like Cry5B) must be used because nematodes are functionally different from insects.
While Bacillus thuringiensis is famous for its insecticidal properties, not all Bt toxins are effective against nematodes. Successful management requires the use of specific Cry proteins, such as Cry5B or Cry6A, which have evolved to target the unique intestinal receptors of nematodes. Because nematodes are biologically and functionally different from lepidopteran or coleopteran insects, these specialized proteins are necessary to achieve effective control in transgenic crops.

108. (B) Ingested proteins bind to intestinal receptors, forming pores that lead to cell lysis.
The nematicidal action of Bt Cry proteins follows a specific biochemical pathway. Once a nematode ingests the proteins, they are activated by proteases in the gut. The active toxins then bind to specific receptors on the surface of the intestinal epithelial cells. This binding leads to the formation of stable pores in the cell membrane, causing cell lysis, gut destruction, and the eventual death of the nematode.

109. (A) Transgenic plants expressing PIs show complete, 100% immunity and instant death to all invading nematodes.
Transgenic approaches to nematode resistance, such as expressing proteinase inhibitors, generally provide partial or quantitative resistance rather than complete immunity. While these plants can significantly reduce nematode growth and reproduction, they rarely cause instant death or eliminate every individual. Therefore, these

technologies are best utilized as part of an integrated management system rather than as a single, absolute solution for nematode control in the field.

110. (D) I, II and III
RNA interference is a biological process where double-stranded RNA molecules inhibit gene expression. In agricultural applications like Host-Induced Gene Silencing, the plant produces these dsRNA triggers. After the nematode ingests the plant material, its own cellular enzymes, specifically DICER, cleave the dsRNA into short interfering RNAs. These siRNAs then guide the degradation of the target messenger RNA, effectively silencing the specific gene.

111. (D) Generating a high-quality genome identifies molecular targets for resistance.
Whole-genome sequencing is a transformative tool in plant nematology. By mapping the entire genetic blueprint of a parasitic nematode, researchers can identify specific genes that are essential for its survival and ability to infect plants. These identified genes serve as high-priority molecular targets for the development of novel management strategies, such as targeted chemical nematicides, biological controls, or transgenic resistance through gene silencing.

112. (C) As a sequenced model, it serves as a baseline for comparative and functional genomics.
Caenorhabditis elegans was the first multicellular organism to have its entire genome sequenced, making it an invaluable model in biology. In the field of nematology, it provides a comprehensive baseline for understanding basic nematode physiology and genetics. Researchers use this information for comparative genomics to identify both conserved genes and those unique to plant parasites, facilitating the discovery of new targets for management.

113. (B) The collection of secreted proteins and effectors produced in the esophageal glands.
The parasitome refers to the complete set of molecules, particularly proteins, that a nematode secretes into its host to facilitate the parasitic process. Most of these "effectors" are produced in the specialized esophageal glands. By studying the parasitome, scientists can understand how nematodes manipulate plant cell functions, suppress the host's immune system, and induce the specialized feeding structures required for their survival and reproduction.

114. (D) Genes encoding plant cell wall-degrading enzymes acquired via horizontal transfer.
Genomic studies of root-knot nematodes have revealed a significant expansion of genes related to plant parasitism. A notable feature is the high number of genes encoding enzymes that degrade plant cell walls, such as cellulases and pectinases. Interestingly, many of these genes appear to have been acquired from bacteria or fungi through horizontal gene transfer, providing the nematodes with the essential tools needed to invade and move within plant tissues.

115. (A) Identifying effectors injected into host cells to induce specialized feeding structures.
The esophageal glands are the primary source of the effectors that sedentary endoparasitic nematodes use to manipulate their hosts. Transcriptomic analysis of these glands allows researchers to identify the specific proteins that are expressed during the infection process. These effectors are injected into plant cells through the stylet, where they orchestrate the formation of specialized feeding sites like giant cells or syncytia.

116. (C) Horizontal gene transfer (HGT) played a crucial role in the evolution of plant parasitism in nematodes.
The presence of genes in nematode genomes that are most similar to those found in bacteria and fungi is strong evidence for horizontal gene transfer. This process involves the movement of genetic material between different species. In phytoparasitic nematodes, the acquisition of microbial genes for cell wall-degrading enzymes was a pivotal evolutionary event, enabling them to transition from free-living organisms to successful plant parasites.

117. (A) A secreted molecule that modulates host physiology or suppresses defenses to aid parasitism.
An effector is a specialized molecule, typically a protein, produced by a nematode and secreted into the host plant tissue. These molecules play diverse and critical roles in the parasitic relationship. They can suppress the plant's natural immune responses, alter the host's metabolic pathways to redirect nutrients, and induce the structural changes in root cells

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necessary for the establishment of a permanent feeding site.

118. (D) Meloidogyne incognita has a highly complex, polyploid, and asexual genome.
The sequencing of the Meloidogyne incognita genome revealed a high level of complexity that reflects its unique biology. As an asexual, polyploid species, its genome contains multiple sets of chromosomes that have diverged over time. This complexity is thought to contribute to the nematode's remarkable ability to adapt to a very wide range of host plants and diverse environmental conditions despite the lack of sexual recombination.

119. (B) It aims to disable the nematode's ability to manipulate the host and establish feeding sites.
Targeting nematode effectors through technologies like Host-Induced Gene Silencing is a sophisticated management strategy. By silencing the genes responsible for producing these secreted proteins, researchers can prevent the nematode from successfully communicating with and manipulating the host cells. This disruption makes it impossible for the parasite to establish the feeding sites it needs to survive, effectively providing resistance to the plant.

120. (B) II only
In the field of nematode omics, the term "parasitome" is inclusive of all proteins and molecules secreted by the parasite to aid its survival within the host. This definitely includes the effectors and enzymes produced in both the dorsal and the subventral esophageal glands. These glands are the primary factories for the various chemical tools that the nematode uses to invade, migrate, and feed.

121. (D) Transcriptomics reveals stage-specific upregulated genes to highlight disruption targets.
Transcriptomics provides a dynamic view of gene activity by measuring the levels of RNA transcripts at different times or under specific conditions. In nematology, this allows for the identification of genes that are specifically upregulated during critical life stages, such as the transition from a free-living juvenile to a parasitic adult. Identifying these stage-specific genes helps researchers pinpoint the most effective targets for disruption.

122. (A) The dorsal gland is predominantly active during the invasion and migration phase in the root.
The esophageal glands of plant-parasitic nematodes have specialized and temporally distinct roles. The two subventral glands are generally more active during the initial stages of the life cycle, secreting enzymes needed for root penetration and migration. In contrast, the dorsal gland becomes more prominent once the nematode has reached its permanent feeding location, where it secretes effectors necessary for inducing and maintaining the specialized feeding site.

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123. (B) The development of microaspiration techniques combined with RNA sequencing (RNA-seq).
Profiling the transcriptome of specific nematode organs like the esophageal glands required significant technical breakthroughs. The use of microaspiration, where researchers use extremely fine needles to collect the contents of individual glands, was a critical development. When combined with highly sensitive RNA sequencing technologies, this allows for the detailed analysis of the parasitism genes expressed by the nematode at a very precise cellular level.

124. (B) The nematode's ability to migrate through the root cortex will be significantly impaired.
Plant cell wall-degrading enzymes are essential for the movement of endoparasitic nematodes within the root. These enzymes, such as cellulases and pectinases, allow the nematode to soften and break through the tough plant cell walls as it migrates toward its feeding site. Using RNAi to silence the genes for these enzymes would significantly hinder the nematode's ability to navigate the root tissues, thereby reducing the success of the infection.

125. (A) Globodera induces syncytia via cell fusion, while Meloidogyne induces giant cells via mitosis.
While both Globodera and Meloidogyne are sedentary endoparasites, they utilize different strategies to create their feeding sites. Globodera species induce the formation of a syncytium, which is created by the dissolution of cell walls and the fusion of neighboring protoplasts. In contrast, Meloidogyne species induce the formation of giant cells, which arise through repeated rounds of nuclear division (mitosis)

77. (A) It has two-way systemicity (ambimobile), translocating via both xylem and phloem after foliar application.
Spirotetramat is unique among systemic nematicides due to its ambimobile nature. When applied as a foliar spray, it is absorbed by the leaves and can move both upward through the xylem and downward through the phloem. This two-way systemicity allows the active ingredient to reach the roots in effective concentrations, providing protection against root-knot and other soil-borne nematodes from a foliar application.

78. (C) It targets a novel neurological pathway distinct from AChE.
Fluensulfone's efficacy is not based on the inhibition of acetylcholinesterase, which is the target of older organophosphate and carbamate nematicides. Instead, it appears to target a novel neurological pathway that affects nematode behavior, development, and locomotion. This distinction is important because it means the chemical can be effective even against nematode populations that have developed resistance to traditional neurotoxic pesticides.

79. (D) Natural or synthetic products with low impact and structural natural parity.
Biorational nematicides are a diverse group of pest control agents designed to have minimal environmental impact. They include natural products, such as botanical extracts and microbial metabolites, as well as synthetic compounds that share structural similarities with natural substances. These agents are characterized by their target specificity, rapid degradation in the environment, and relatively low toxicity to non-target organisms, including humans and beneficial insects.

80. (A) I, II, IV, III
The history of chemical nematode control has evolved through several distinct phases. It began with the widespread adoption of broad-spectrum fumigants like methyl bromide. This was followed by the development of neurotoxic non-fumigants like organophosphates and carbamates. Later, concerns about environmental safety led to the banning of older chemicals like DBCP, eventually leading to the discovery of modern, targeted SDHI nematicides.

81. (B) Azadirachtin
Azadirachtin is the most well-known and potent nematicidal compound found in the seeds and leaves of the neem tree. It belongs to a group of chemical substances called limonoids. Azadirachtin acts as a powerful antifeedant, repellent, and growth regulator for various pests. In nematodes, it interferes with molting, reduces egg hatching, and disrupts their development, making it a cornerstone of organic nematode management.

82. (D) They are produced by the fermentation of the soil actinomycete Streptomyces avermitilis.
Avermectins are a group of powerful bioactive compounds used extensively in agriculture and medicine. These natural products are produced as secondary metabolites during the fermentation of a specific soil-dwelling actinomycete, Streptomyces avermitilis. Abamectin, a common avermectin used as a nematicide, provides high levels of efficacy at very low application rates, making it an important tool in modern, sustainable pest control strategies.

83. (A) It binds to glutamate-gated chloride channels, increasing chloride ion permeability and causing flaccid paralysis.
Abamectin functions by disrupting the normal transmission of nerve impulses in nematodes. It specifically binds to glutamate-gated chloride channels located in the nerve and muscle cells. This binding increases the permeability of the cell membrane to chloride ions, leading to hyperpolarization and the suppression of electrical activity. The result is a flaccid paralysis of the nematode, preventing movement, feeding, and reproduction.

84. (C) They are highly persistent in the soil, remaining active for several years after a single application.
Azadirachtin is valued for its environmental safety, partly because it is not persistent in the soil. Like many botanical extracts, it degrades relatively quickly due to microbial activity and exposure to ultraviolet light. While this necessitates more frequent applications compared to some synthetic chemicals, it ensures that the compound does not accumulate in the environment or pose long-term risks to non-target soil organisms.

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134. (D) They offer instant, 100% knockdown of nematode populations comparable to methyl bromide.
Organic amendments like neem cake are valuable tools for long-term soil health and pest management, but they do not provide the instant, broad-spectrum knockdown effect of chemical fumigants. Their action is slower and more complex, relying on the gradual release of bioactive compounds and the stimulation of natural soil antagonists. Therefore, they are best viewed as a component of a sustainable, integrated management approach.

135. (B) Low $C{:}N$ ratios lead to rapid decomposition and quick release of nematicidal ammonia.
The carbon-to-nitrogen ratio is a fundamental factor determining the nematicidal efficacy of organic amendments. Materials with a low $C{:}N$ ratio, such as oil cakes and certain animal manures, decompose rapidly in the soil. this fast microbial breakdown leads to the release of high concentrations of ammonia, which is directly toxic to nematodes, providing a more immediate and effective level of pest suppression.

136. (C) It colonizes the rhizosphere and releases metabolites that repel or harm nematodes.
Pseudomonas fluorescens is a beneficial soil bacterium that acts as a potent biological control agent. When applied to the soil or seeds, it aggressively colonizes the rhizosphere, the area of soil immediately surrounding the plant roots. Once established, the bacteria produce various secondary metabolites and antibiotics that can directly kill or repel nematodes and interfere with their ability to find and infect the host.

137. (D) A mycelial, endospore-forming, obligate bacterial parasite of nematodes.
Pasteuria penetrans is a specialized and highly effective natural enemy of root-knot nematodes. It is an obligate bacterium, meaning it can only complete its life cycle inside its nematode host. It is characterized by its ability to form environmentally resistant endospores and a mycelial growth phase within the nematode body. Its high specificity and persistence make it a prime candidate for long-term biological control.

138. (A) Both are primarily known as parasites of nematode eggs and sedentary females.
Pochonia chlamydosporia and Purpureocillium lilacinum are two of the most important fungal biological control agents in nematology. Both species share a similar ecological niche, specializing as parasites of the sedentary stages of plant-parasitic nematodes. They are particularly effective at infecting and destroying nematode eggs and the females that remain associated with the roots, providing a significant reduction in the next generation of pests.

139. (B) Using transparent polyethylene during peak solar periods to maximize heat trapping.
The success of soil solarization depends on maximizing the accumulation of solar energy in the soil. Using thin, transparent polyethylene film is more effective than opaque or black films because it allows short-wave solar radiation to pass through and heat the soil, while its greenhouse effect traps the resulting long-wave heat. This process is most effective during the peak summer months when solar intensity is highest.

140. (A) Both A and R are true and R is the correct explanation of A.
Organophosphate and carbamate nematicides share a common biochemical mode of action centered on the nervous system. They both work by inhibiting the enzyme acetylcholinesterase, which is essential for the proper termination of nerve signals. This inhibition leads to an accumulation of acetylcholine, causing continuous muscle contraction or paralysis. This disruption of coordinated movement prevents the nematode from feeding or locating host roots, eventually leading to death.

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141. (A) Time is required for the toxic gas to dissipate from the soil to prevent phytotoxicity to the newly planted crop.
Soil fumigants like 1,3-Dichloropropene are highly effective because of their toxicity and volatility. However, the same properties that make them lethal to nematodes also make them harmful to young plants. A mandatory waiting period after application allows the gaseous chemical to diffuse through the soil and eventually dissipate into the atmosphere. This ensures that the soil environment is safe for seed germination and crop establishment.

142. (C) The application of nematicides to the soil through irrigation water.
Nemigation is a specialized form of chemigation focused on the delivery of nematicides. It involves injecting liquid or water-soluble nematicide formulations directly into an irrigation system, such as drip or sprinkler lines. This method allows for the precise and uniform distribution of the chemical throughout the root zone. Nemigation is particularly valuable for managing nematodes in established orchards or high-value vegetable crops under irrigation.

143. (D) It regulates the import of agricultural commodities to prevent the entry, establishment, and spread of exotic pests and diseases.
The Plant Quarantine Order is the cornerstone of India's biosecurity framework for agriculture. Its primary function is to provide a legal and regulatory basis for controlling the import of plants and plant products. By enforcing inspections, certifications, and risk analyses, the PQO aims to protect the nation's agriculture from the introduction of invasive exotic pests, including highly destructive nematode species not yet present in the country.

144. (C) It is Globodera rostochiensis.
The "Golden Nematode" is a common name for the potato cyst nematode, specifically the species Globodera rostochiensis. This pest is a major concern in the Nilgiri region of India, where it was first discovered. The name "golden" comes from the distinct golden-yellow color that the adult females turn before they mature into the final brown, protective cyst stage that persists in the soil.

145. (B) It evaluates pest entry, establishment, and spread likelihood and economic impact.
Pest Risk Analysis is a science-based, systematic process used to justify quarantine regulations. It involves a detailed evaluation of various factors, including the probability of a pest entering a new area, the likelihood of it becoming established given the local climate and host availability, and its potential to cause economic or environmental damage. The PRA provides the technical evidence required under international trade agreements.

146. (D) An international phytosanitary certificate completely overrides and nullifies the importing country's quarantine laws.
Phytosanitary certification is an official process that facilitates international trade while protecting plant health. However, the certificate does not override the laws of the importing country. Instead, it is a document that confirms the shipment has been produced and inspected in accordance with the specific requirements set by those laws. The importing country always maintains the right to inspect and regulate arrivals according to its national standards.

147. (A) Pre-infectional mechanisms exist constitutively before nematode attack, while post-infectional mechanisms are activated in response to nematode penetration.
Plants possess two main categories of defense mechanisms against nematodes. Pre-infectional or constitutive defenses are always present, such as thick cell walls or pre-existing toxic chemicals in the roots. Post-infectional or induced defenses are only triggered after the plant recognizes the presence of a nematode. These include the rapid synthesis of defensive compounds or the induction of localized cell death to prevent further infection.

148. (C) Recognition of specific nematode-associated molecular patterns or effectors (Avr products) by the plant's resistance (R) proteins.
The hypersensitive response is triggered by a highly specific molecular recognition event. It occurs when the plant's resistance proteins detect either conserved molecular patterns on the nematode or specific "avirulence" effectors injected by the pest. This recognition acts like a biological alarm, signaling the plant to initiate a series of rapid defense responses, including the localized cell death that isolates and starves the invading nematode.

149. (A) As long-distance attractants (kairomones) that guide infective juveniles toward the root tips.
Root exudates are a complex mixture of chemicals released by plants into the surrounding soil. For many plant-parasitic nematodes, these exudates serve as critical host-finding cues. Known as kairomones, these chemical attractants create a concentration gradient that the infective juveniles follow to locate the most vulnerable

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parts of the root system, such as the zone of elongation, where they can initiate infection.

150. (B) P-3, Q-1, R-4, S-2
Nematicides and biological agents have diverse modes of action. Abamectin is a fermentation product that activates chloride channels, while Arthrobotrys oligospora is a fungus that traps nematodes with adhesive nets. Metam sodium acts as a precursor for methyl isothiocyanate gas. Fluopyram is a modern SDHI that inhibits mitochondrial respiration. Understanding these different mechanisms is essential for designing effective and sustainable nematode management programs.

151. (B) The plant must produce the dsRNA in specific root tissues where the pest feeds.
The success of Host-Induced Gene Silencing depends on the effective delivery of the silencing signal. Since most plant-parasitic nematodes feed specifically on root tissues, the transgenic plant must be engineered to express the double-stranded RNA triggers in those locations. Ensuring that the dsRNA is present in the feeding sites, such as giant cells or syncytia, maximizes the likelihood that the nematode will ingest the molecules.

152. (C) The female nematodes will be unable to produce fertilized eggs, leading to population decline.
Major sperm proteins are essential for the fertility and reproductive success of many nematode species. If an RNAi strategy successfully silences the gene responsible for these proteins, the males will be unable to produce viable sperm. As a result, the females will fail to produce fertilized eggs. Over time, this disruption of the reproductive cycle leads to a significant and sustained decline in the nematode population.

153. (D) It is a member of the nucleotide-binding leucine-rich repeat (NLR) class of plant resistance genes.
The Mi-1.2 gene belongs to the large and important NLR class of plant resistance genes. These genes encode proteins that act as intracellular receptors, monitoring the cell for signs of pathogen or pest attack. The structure of the Mi-1.2 protein allows it to recognize specific nematode signals and then initiate the complex signaling pathways that lead to the hypersensitive response and overall host resistance.

154. (A) Hisar Lalit - Tomato - Root-knot nematode
Development of resistant cultivars is a key goal in plant breeding. The tomato variety Hisar Lalit is a well-known example specifically bred for resistance against root-knot nematodes. Utilizing such resistant varieties provides a sustainable and cost-effective management tool for farmers, significantly reducing the reliance on chemical nematicides while maintaining high productivity in fields infested with Meloidogyne species.

155. (B) By degrading the syncytium after initial formation, leading to starvation and a shift towards male development.
The Hs1pro-1 gene confers resistance to the sugarbeet cyst nematode through a specific post-infectional mechanism. After the nematode initiates the formation of a syncytium, the resistance gene causes this feeding site to degrade prematurely. This deprives the developing nematode of essential nutrients. In many cyst nematodes, this lack of nutrition leads to the death of the juvenile or forces it to develop into a male.

156. (B) Effective crop rotation requires alternating a susceptible crop with a non-host or highly resistant crop to disrupt the nematode's life cycle.
Crop rotation is a fundamental cultural practice in nematode management. Its success depends on the strategic use of non-host or resistant plants that do not allow the nematode to reproduce. By interrupting the pest's life cycle for one or more seasons, the soil population naturally declines due to starvation and predation, reducing the risk of damage when a susceptible crop is eventually replanted.

157. (A) Fallowing is universally adopted because it maximizes farmer income during the fallow period.
Although fallowing is an effective biological method for reducing nematode populations, it is far from universally adopted. The primary drawback is the economic cost; leaving land uncultivated means the farmer receives no income from that land for an entire season. This financial burden makes fallowing a difficult choice for many farmers, especially those with small holdings who rely on continuous production for their livelihoods.

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158. (C) To combine multiple tactics to manage pests sustainably.
Integrated Nematode Management is based on the principle of using a combination of different, compatible control methods. The objective is not to rely on any single tactic, such as chemical fumigation, but to integrate cultural, biological, and genetic tools. This multi-faceted approach aims to keep nematode populations below the economic threshold in a way that is environmentally responsible, economically viable, and sustainable for the long term.

159. (D) Using solarization followed by enriched FYM and growing tolerant plant varieties.
A rational integrated management module for protected agriculture combines preventive and curative methods. Starting with soil solarization reduces the initial pest load. Following this with the application of farmyard manure enriched with biological control agents like Trichoderma or Purpureocillium helps maintain a suppressive soil environment. Finally, selecting tolerant or resistant varieties provides an additional layer of protection throughout the growing season.

160. (C) Migratory endoparasites
Root-lesion nematodes, belonging to the genus Pratylenchus, are classified as migratory endoparasites. Unlike sedentary nematodes that stay in one spot, these pests move continuously through the root cortex as they feed. Both juveniles and adults can enter and exit the roots, causing extensive mechanical damage and creating necrotic lesions. This mobile feeding behavior distinguishes them from root-knot and cyst nematodes that establish permanent feeding sites.

161. (B) Meloidogyne induces giant cells, while Pratylenchus creates cortical necrotic lesions.
Meloidogyne and Pratylenchus utilize very different parasitic strategies. Meloidogyne is a sedentary endoparasite that induces the formation of specialized, multinucleate giant cells to serve as a permanent food source. In contrast, the migratory Pratylenchus does not induce such structures. Instead, its constant movement and feeding within the root cortex lead to the death of plant cells and the formation of dark, necrotic lesions.

162. (D) It causes rapid inhibition of development and locomotion without inhibiting AChE.
Fluensulfone is a modern nematicide that represents a new chemical class with a unique mode of action. Unlike many older pesticides, it does not work by inhibiting the enzyme acetylcholinesterase. Instead, it appears to target other aspects of nematode physiology, leading to a rapid cessation of movement, feeding, and development. This distinct mechanism makes it a valuable alternative for managing populations that may have developed resistance to traditional chemistries.

163. (A) Most have strong acropetal movement but weak basipetal movement, making foliar use poor.
The effectiveness of foliar-applied systemic nematicides is often limited by the plant's internal transport systems. Most of these chemicals move primarily through the xylem, which translocates water and nutrients upward from the roots to the leaves (acropetal). Movement through the phloem (basipetal), which would carry the chemical from the leaves down to the roots where most nematodes are located, is generally much weaker and often insufficient.

164. (C) A compound that paralyzes or disorients nematodes without directly killing them, though prolonged exposure may lead to death via starvation.
A nematistat is a type of chemical agent that interferes with the normal behavior and movement of nematodes without causing immediate mortality. These compounds often work by disrupting the nematode's nervous system or sensory perception, leading to paralysis or disorientation. By preventing the nematode from finding or penetrating host roots, nematistats effectively stop crop damage, though the pests may eventually die from starvation.

165. (A) The messenger RNA (mRNA) transcript of a specific gene
In the process of RNA interference, the primary target of the silencing machinery is the messenger RNA. mRNA serves as the template for protein synthesis. By introducing double-stranded RNA that is homologous to a specific mRNA transcript, the RNAi mechanism triggers the degradation of that mRNA. This prevents the corresponding protein from being produced,

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effectively silencing the gene's function without altering the underlying DNA.

166. (D) The term 'virulence' refers to the ability of a nematode population to reproduce on a resistant plant variety.
In the context of plant pathology and nematology, virulence has a specific meaning related to the interaction between a pest and a resistant host. It refers to the ability of a particular individual or population of nematodes to overcome the resistance mechanisms of a plant cultivar and successfully reproduce. Understanding the distribution of virulent biotypes is essential for the effective deployment of resistant crop varieties.

167. (B) They are populations of a nematode species capable of breaking the resistance of specific host cultivars.
Nematode biotypes or pathotypes are distinct populations within a single species that differ in their ability to infect and reproduce on specific host plants. These variations are often genetically determined. The existence of these biotypes is a significant challenge in agriculture, as a resistant variety that works in one location may be susceptible to a different pathotype of the same nematode species in another region.

168. (C) It provides a 100% guarantee that the shipment is completely free of all known microbes.
While phytosanitary certification is a rigorous process, it cannot provide an absolute 100% guarantee that a shipment is completely free of all microorganisms. The certification is based on established protocols for inspection, sampling, and testing for specific regulated quarantine pests. It indicates a high level of confidence that the shipment meets the importing country's requirements, but it is not an indicator of total microbial sterility.

169. (D) To prevent the spread of the potato cyst nematode into major potato-growing zones.
The domestic quarantine imposed in the Nilgiri Hills is a critical strategic measure for India's potato industry. By restricting the movement of seed tubers and soil from this infested region, authorities aim to prevent the introduction of the highly destructive potato cyst nematode into the massive potato production areas of the northern plains. This containment effort is essential for protecting the national food supply and agricultural economy.

170. (A) It turns the soil over, bringing deep-dwelling nematodes and eggs to the surface where they are killed by solar radiation and dry wind.
Deep summer ploughing is an effective cultural practice that leverages natural environmental stressors. By inverting the soil during the hottest months, nematodes and their reproductive structures are brought to the surface. Exposure to the intense heat of solar radiation and the drying effects of summer winds leads to their death through desiccation and thermal stress, significantly reducing the soil-borne population before planting.

171. (B) Low toxicity to non-target organisms, rapidly degrading, and having minimal environmental impact.
Bio-rational pesticides are designed to be more selective and environmentally friendly than traditional broad-spectrum chemicals. They typically have low toxicity to mammals, birds, and beneficial insects. Furthermore, these products are often derived from natural sources or are synthetic analogs that degrade quickly in the environment. This rapid breakdown prevents the accumulation of toxic residues in soil or water, making them suitable for sustainable agriculture.

172. (B) Highly toxic chemicals are being phased out in favor of target-specific bio-rationals.
The agricultural industry is undergoing a significant transition in how pests are managed. Due to increasing regulatory pressure and concerns about human health and environmental safety, many older, highly toxic nematicides are being phased out or severely restricted. This shift is driving the development and adoption of modern bio-rationals and target-specific chemistries that offer effective control with much lower risks to non-target organisms.

173. (A) Incorporating them uniformly into the soil followed by light irrigation to dissolve and distribute the active ingredient.
The efficacy of granular nematicides depends on their proper placement and activation in the soil. These products must be uniformly incorporated into the soil to ensure they are present throughout the root zone. Following application, a light irrigation is often necessary to help dissolve the

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ensuring that the resistance genes remain effective for a longer period in the field.

190. (A) Both A and R are true and R is the correct explanation of A.
Transgenic plants using RNA interference offer a powerful new tool for nematode management. By expressing double-stranded RNA that matches essential nematode genes, the plant can trigger a silencing response in the pest. When the nematode feeds and ingests these dsRNA molecules, its internal RNAi machinery degrades the corresponding messenger RNA. This prevents the production of vital proteins, leading to a significant reduction in the nematode's ability to survive.

191. (D) To induce hatching and then destroy the crop early.
The catch crop strategy is a targeted cultural management tactic. It utilizes a susceptible host to act as a biological "trap." The crop is planted to stimulate the hatching of nematode eggs in the soil and encourage the juveniles to infect the roots. Crucially, the crop is then physically removed or destroyed before the nematodes can complete their life cycle, effectively eliminating a portion of the population from the field.

192. (C) It generally reduces impact by boosting plant vigor and fostering diverse natural enemies.
Increasing soil organic matter is a foundational practice in sustainable agriculture that provides multiple benefits for nematode management. It improves soil structure and water-holding capacity, which boosts overall plant vigor and tolerance to damage. Furthermore, organic matter supports a rich and diverse community of soil microorganisms, including many natural antagonists like predatory fungi and bacteria that help keep plant-parasitic nematode populations in check.

193. (B) Systemic and Non-systemic
Nematicides can be classified based on how they move within the target plant after application. Systemic nematicides are absorbed by the plant tissues and translocated through the vascular system, providing protection throughout the plant. Non-systemic or contact nematicides, on the other hand, do not enter the plant's internal systems; instead, they remain in the soil or on the root surface, acting directly on the nematodes they come into contact with.

194. (D) ECs form a true solution in water, while WPs form a suspension that requires continuous agitation to prevent settling.
Emulsifiable concentrates and wettable powders behave differently when mixed with water for application. ECs are liquid formulations that form a stable emulsion, where oil-based particles are dispersed. WPs are dry, finely ground powders that do not dissolve but instead form a suspension of solid particles. Because these solid particles tend to settle at the bottom of the spray tank, WPs require constant agitation to ensure a uniform application concentration.

195. (A) The use of anti-siphon backflow devices to prevent primary water source contamination.
Safety is a paramount consideration when using chemigation to apply pesticides. A critical requirement is the installation of anti-siphon backflow prevention devices. These devices ensure that if the irrigation pump fails or the pressure drops, the chemical-laden water cannot flow backward into the primary water source, such as a well or stream. This protects the environment and public water supplies from potential chemical contamination.

196. (C) Successive use may cause enhanced microbial degradation which reduces field efficacy.
Repeated and continuous use of certain non-fumigant nematicides in the same field can lead to a phenomenon known as enhanced microbial degradation. Over time, the soil's microbial community adapts to the presence of the chemical, developing the ability to rapidly break it down and use it as a source of carbon or energy. This accelerated degradation significantly reduces the chemical's persistence and effectiveness in the root zone.

197. (A) Rapid localized cell death at the infection site that restricts nutrient spread to the pest.
The hypersensitive response is an active defense mechanism characterized by rapid, programmed cell death in the tissues immediately surrounding a pathogen or pest. By sacrificing these localized cells, the plant creates a zone of necrotic tissue that lacks the nutrients needed by biotrophic organisms. This effectively isolates the invading nematode, preventing it from establishing the specialized feeding site it requires for growth and eventual reproduction.

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chemical pesticides can all lead to failure. To be effective, these agents must be carefully managed to ensure they can survive, establish, and multiply in the complex soil environment.

182. (D) They are active in pre-parasitic stages to secrete cell wall-degrading enzymes.
In the life cycle of sedentary endoparasites like root-knot nematodes, the subventral esophageal glands have a critical early-stage function. They are highly active in the infective, pre-parasitic second-stage juveniles. These glands produce and secrete various cell wall-degrading enzymes, such as cellulases and pectinases, which the nematode uses to soften and penetrate the root tissues and migrate toward the vascular cylinder to establish its feeding site.

183. (B) Subventrals are active during migration, while the dorsal maintains feeding sites later.
The esophageal glands of sedentary parasitic nematodes exhibit a distinct functional shift during development. The two subventral glands are primarily responsible for the enzymes needed during the initial stages of root invasion and internal migration. Once the nematode becomes sedentary, the dorsal gland takes over the primary role, secreting the specific effectors required to induce and maintain the complex multinucleate giant cells or syncytia used for feeding.

184. (C) The presence of numerous saucer-shaped endospores adhering to the cuticle of the juvenile nematodes.
Infection by the bacterium Pasteuria penetrans can be identified by examining the motile juveniles of root-knot nematodes under a microscope. The most characteristic sign is the presence of small, saucer-shaped endospores that firmly adhere to the nematode's cuticle. These spores are the infective stage of the bacterium and their attachment is the first step in a process that eventually leads to the sterilization of the host.

185. (D) It exhibits a high degree of specificity with biotypes only adhering to specific populations.
Pasteuria penetrans is known for its remarkable level of host specificity. Research has shown that different biotypes or strains of the bacterium are often restricted to infecting only specific species or even specific populations of nematodes. This specificity is determined by the compatibility between the surface of the bacterial endospore and the cuticle of the target nematode, making it a highly targeted biological control agent.

186. (A) Soil where pests fail to establish due to natural enemies.
A suppressive soil is an environment where a specific pest or pathogen does not cause significant damage, even when a susceptible host and favorable climate are present. This suppression is primarily biological, resulting from a high diversity and activity of natural antagonists, such as predatory nematodes, nematophagous fungi, and antagonistic bacteria. These soils are valuable examples of natural biological control and are extensively studied in integrated pest management.

187. (B) Because its wide and polyphagous host range makes finding non-host crops difficult.
Meloidogyne incognita is one of the most challenging nematodes to manage through crop rotation because it is highly polyphagous. It can successfully feed and reproduce on hundreds of different plant species, including many major vegetables, cereals, and common weeds. This extremely broad host range makes it very difficult for farmers to find suitable non-host crops that are also economically viable to include in a rotation sequence.

188. (B) It serves to protect the extruded eggs from desiccation, microbial attack, and some chemical nematicides.
The gelatinous matrix is a specialized protective substance produced by the rectal glands of adult female root-knot nematodes. It serves as an external envelope that encloses and protects the eggs after they are laid. This matrix is essential for the survival of the embryos, as it provides a barrier against dehydration, predation by soil organisms, and infection by certain soil-borne microbes and chemical stresses.

189. (A) Rotating varieties with non-hosts prevents selection of resistance-breaking biotypes.
Using host resistance effectively in the long term requires careful management to prevent the emergence of virulent nematode populations. Continuous planting of the same resistant variety can create strong selection pressure, favoring individuals that can bypass the resistance. By rotating resistant cultivars with non-host crops, farmers can disrupt this selection process,

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206. (C) Trap crops attract and allow penetration before early destruction; non-hosts prevent it entirely.
Trap crops and non-host crops function through different ecological mechanisms. A non-host crop does not support the nematode's life cycle, often preventing penetration or survival within the root entirely. In contrast, a trap crop is a susceptible host that actively attracts the nematodes and allows them to enter the roots. The management effect is achieved by physically destroying the trap crop before the nematodes can complete their development.

207. (D) Maximum daytime temperatures exceeding 40°C and very low soil moisture.
The effectiveness of deep summer ploughing as a management tactic is highly dependent on specific climatic conditions. It is most successful in regions with intense summer heat, where daytime temperatures frequently exceed 40 degrees Celsius, and low soil moisture levels. These extreme conditions maximize the rate of desiccation and thermal death for nematodes and their eggs that are brought to the surface during the ploughing process.

208. (C) High yield loss per individual nematode results in a correspondingly low Economic Injury Level.
The damage coefficient quantifies the impact of each individual pest on the total yield of a crop. A high damage coefficient indicates that the nematode is particularly destructive and that even a small population can cause significant financial loss. In such cases, the Economic Injury Level is set at a low population density because the threshold where the cost of control equals the value of saved yield is reached very quickly.

209. (B) A formulated product containing a biological agent used to manage nematode populations.
A bionematicide is a specialized type of pesticide formulated from biological sources rather than synthetic chemicals. These products may contain living microorganisms, such as beneficial fungi or bacteria, or their natural metabolic byproducts that have nematicidal properties. Bionematicides offer a more sustainable and targeted approach to nematode management, often having lower impacts on the environment and non-target organisms compared to traditional chemical soil treatments.

210. (A) I and II
Proper sampling is the foundation of accurate nematode diagnosis and management. Because many plant-parasitic nematodes reside within or near the roots, samples should ideally include both soil and fine feeder roots. Furthermore, to maintain the viability of the nematodes for laboratory assay, samples must be kept cool and moist during transit, as exposure to extreme heat or desiccation can lead to the death and loss of the target pests.

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211. (A) Wild potato species such as Solanum tuberosum ssp. andigena and S. vernei
Breeding for resistance against the potato cyst nematode, Globodera pallida, has relied heavily on genetic diversity found in wild relatives. Significant sources of resistance have been identified in species such as Solanum tuberosum subspecies andigena and Solanum vernei. These wild species possess genes that can be introgressed into cultivated potato varieties, providing essential tools for managing this highly destructive and long-lived soil-borne pest in major production regions.

212. (C) The water acts as the vehicle to distribute the chemical down into the root zone where the nematodes reside.
When applying contact or non-fumigant nematicides, the volume of water used is a critical technical factor. Since these chemicals do not move as a gas, they must be physically carried into the soil profile. The water serves as the vehicle, helping to transport the active ingredient from the soil surface down into the root zone. This ensures that the nematicide reaches the specific areas where the nematodes are actively feeding.

213. (A) It disrupts nematode molting, acts as a feeding deterrent, and reduces egg hatching.
Azadirachtin, the primary bioactive compound in neem, utilizes multiple physiological and behavioral mechanisms to manage nematodes. It acts as a growth regulator by disrupting the complex hormonal signals needed for molting. Additionally, it serves as a feeding deterrent and can significantly reduce the number of eggs that successfully hatch. This multi-targeted approach provides effective suppression of plant-parasitic nematodes while maintaining a high level of safety for the soil environment.

198. (D) For every dominant resistance gene (R) in the host, there is a corresponding dominant avirulence gene (Avr) in the pathogen/nematode. The gene-for-gene hypothesis is a fundamental concept in plant pathology that describes the molecular basis of many resistance interactions. It states that host resistance occurs only when a specific resistance gene in the plant recognizes a corresponding "avirulence" gene product from the pathogen. If either the plant lacks the R gene or the pathogen lacks the Avr gene, the recognition does not occur, and the plant remains susceptible to infection.

199. (B) It involves inhibition of lipid biosynthesis and reproduction, acting as a two-way systemic agent.
Spirotetramat is a modern pesticide with a unique physiological impact on nematodes. It works primarily by inhibiting the biosynthesis of lipids, which are essential for many cellular processes and energy storage. This disruption significantly impairs the development and reproduction of the pest. Its ambimobile nature allows it to be applied foliarly and translocated to the roots, where it provides effective suppression of various soil-borne nematode species.

200. (A) P-4, Q-3, R-2, S-1
Modern nematode research utilizes several biotechnological terms and methods. The transcriptome represents the complete set of RNA transcripts in a cell. RNAi is the underlying mechanism of gene silencing using dsRNA, while HIGS is the specific delivery method through a host plant. Effectors are the secreted proteins that nematodes use to manipulate their host. Together, these concepts provide the foundation for developing next-generation nematode management strategies.

201. (D) Genomics reveals unique genes in parasitic nematodes likely acquired via horizontal transfer.
Genomic analysis has provided profound insights into the evolution of plant parasitism in nematodes. One of the most significant findings is the discovery of numerous genes encoding cell wall-degrading enzymes that are most similar to those found in soil bacteria and fungi. This indicates that horizontal gene transfer was a critical evolutionary driver, providing nematodes with the essential genetic tools needed to successfully transition to a plant-parasitic lifestyle.

202. (A) Because it is a devastating plant parasite, studying its root-invasion mechanisms is highly applicable.
Caenorhabditis elegans is an essential model organism in biology, but it is not a plant-parasitic nematode. Instead, it is a free-living soil nematode that primarily feeds on bacteria. While it does not invade plants, its well-mapped genome and nervous system make it a powerful tool for studying basic biological processes, genetics, and neurotransmission that are common to all nematodes, including those that are major agricultural pests.

203. (B) HIGS uses small specific RNA molecules to minimize off-target environmental effects.
Host-Induced Gene Silencing offers a distinct advantage in terms of target specificity compared to many other transgenic technologies. By utilizing small, sequence-specific RNA molecules, HIGS can be designed to target only the genes of a specific pest species. This precision minimizes the risk of affecting non-target organisms, such as beneficial soil microbes or insects, providing a more environmentally sustainable approach to crop protection than broad-spectrum chemicals or toxins.

204. (B) Targeted necrosis prevents the establishment of giant cells and starves the infective J2.
When a resistant plant mounts a hypersensitive response against Meloidogyne, it induces rapid cell death at the point of infection. This targeted necrosis prevents the nematode from successfully initiating the formation of the specialized multinucleate giant cells it needs to feed. Without access to these essential nutrients, the infective second-stage juvenile is unable to grow or develop further, eventually leading to its death and the failure of the infection.

205. (A) Induced (Post-infectional)
Phytoalexins are classified as induced or post-infectional biochemical defenses. These antimicrobial compounds are not present in healthy plant tissues but are synthesized de novo specifically in response to a pathogen or pest attack. Once the plant recognizes the presence of a nematode, it activates the metabolic pathways necessary to produce these toxic chemicals at the site of infection, helping to inhibit the growth and reproduction of the parasite.

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granules and distribute the active ingredient into the soil solution, where it can come into contact with the nematodes.

174. (C) Narrow stylet orifices limit protein uptake, necessitating transgenic delivery methods.
Applying Bacillus thuringiensis directly to soil-borne nematodes is challenging because of their specialized feeding anatomy. Many plant-parasitic nematodes have extremely narrow stylet orifices that prevent the ingestion of large, intact Bt crystalline proteins. To overcome this, transgenic technology is used to express the toxins directly within the plant cells. This allows the nematode to ingest the smaller, solubilized toxins while feeding on the host tissue.

175. (D) They are specialized mycelial loops that physically inflate to trap passing nematodes.
Constricting rings are one of the most sophisticated trapping mechanisms found in certain predatory soil fungi. These structures consist of three specialized mycelial cells that form a small loop. When a nematode swims through the ring, the mechanical stimulus causes the cells to rapidly inflate inward, physically seizing and crushing the pest. Once captured, the fungus then penetrates and digests the nematode for nutrients.

176. (C) Isothiocyanates (derived from glucosinolates)
Biofumigation is a management technique that utilizes the natural chemical defenses of cruciferous plants. When these plants are crushed and incorporated into the soil, the enzyme myrosinase breaks down glucosinolates to release volatile and highly toxic isothiocyanates. These natural sulfur-containing compounds act as powerful fumigants, effectively suppressing various soil-borne pests, including plant-parasitic nematodes, while also improving soil organic matter and overall microbial health.

177. (A) It is known as biofumigation.
Biofumigation is a specialized cultural and biological management strategy that uses specific cover crops, primarily from the Brassicaceae family. The process involves growing these crops and then macerating the green biomass before incorporating it into the soil. The subsequent release of volatile, toxic metabolites during decomposition provides a natural fumigation effect, reducing the population of nematodes and other soil-borne pathogens in a sustainable manner.

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178. (D) It uses enzymatic breakdown of glucosinolates into toxic soil-borne isothiocyanates.
The scientific basis of biofumigation lies in a specific chemical reaction. Cruciferous plants contain compounds called glucosinolates and an enzyme called myrosinase in separate cellular compartments. When the plant tissue is mechanically damaged and incorporated into moist soil, the enzyme and substrate react to produce isothiocyanates. These volatile molecules are toxic to a wide range of nematodes, providing an effective alternative to synthetic soil fumigants.

179. (A) They act instantaneously as contact poisons within minutes of application to the soil surface.
Oil cakes do not provide the immediate, rapid knockdown effect associated with synthetic contact poisons. Their nematicidal activity is a gradual process that depends on microbial decomposition in the soil. As the organic material breaks down over several weeks, it releases various toxic byproducts like ammonia and phenolic compounds. This time-dependent action means that they must be applied well before planting to be effective and safe.

180. (C) Incorporation of biomass releases toxic organic acids and stimulates antagonistic soil flora.
Green manuring contributes to nematode management through multiple biochemical and biological pathways. As the incorporated biomass decomposes, it releases a variety of organic acids and volatile compounds that are directly harmful to nematodes. Furthermore, the addition of large amounts of organic matter stimulates the growth of beneficial soil microbes, including natural predators and parasites that provide sustained suppression of the plant-parasitic nematode population.

181. (A) Poor formulation, harsh environmental conditions (extreme heat/dryness), or incompatibility with simultaneously applied chemical pesticides.
The success of biological control agents is often more variable than that of synthetic chemicals due to their living nature. Factors such as poor product formulation, exposure to extreme heat or soil desiccation, and the presence of incompatible

214. (D) A single season of non-host rotation is sufficient to completely eradicate PCN from a field.
Crop rotation is a cornerstone of managing the potato cyst nematode, but it is not a quick solution. Because the protective cysts can remain viable in the soil for 10 to 20 years, a single season of non-host rotation is never sufficient to eradicate the population. Effective management requires long-term rotations involving multiple years of non-host crops to allow the natural, slow decline of the cyst population through spontaneous hatching and natural predation.

215. (B) To prevent the introduction, establishment, and spread of exotic pests across borders.
Phytosanitary regulations, such as those detailed in the Plant Quarantine Order, are essential for national biosecurity. Their primary conceptual aim is to protect domestic agriculture from the devastating impacts of exotic pests and diseases. By regulating the movement of agricultural commodities through inspections and certifications, these laws help prevent the accidental introduction of non-native species that could cause significant economic losses and disrupt entire agricultural ecosystems.

216. (C) It colonizes the emerging radicle to provide early protection against invading nematodes.
Applying beneficial bacteria like Pseudomonas fluorescens as a seed treatment is a strategic decision for early plant protection. Once the seed germinates, the bacteria rapidly colonize the emerging radicle and young root tissues. By establishing a strong presence in the rhizosphere from the very beginning, they can repel infective juveniles and provide a biological barrier that protects the plant during its most vulnerable stage of development.

217. (D) Bio-rational/botanical nematicides
Essential oils derived from plants like garlic, thyme, or mustard are classified as bio-rational or botanical nematicides. These natural products contain various volatile organic compounds that exhibit direct toxicity or repellent effects against nematodes. They are increasingly valued in integrated pest management and organic farming because they generally have a low toxicity to mammals and non-target organisms and degrade rapidly in the environment without leaving persistent harmful residues.

218. (A) Low $C{:}N$ ratios release ammonia rapidly, while high $C{:}N$ materials lead to nitrogen immobilization.
The $C{:}N$ ratio of an organic amendment significantly dictates its decomposition pathway and nematicidal potential. Materials with a low $C{:}N$ ratio break down quickly, leading to the rapid release of ammonia, which is highly toxic to many nematode life stages. In contrast, materials with a high $C{:}N$ ratio decompose more slowly and can cause nitrogen immobilization, where soil microbes consume available nitrogen, potentially reducing the amendment's immediate effectiveness.

219. (B) Using single constructs to target multiple essential genes to increase efficacy and reduce resistance.
A multiplex or combination RNAi strategy is designed to improve the robustness and durability of nematode resistance. By targeting several different essential genes simultaneously within a single construct, the strategy increases the overall pressure on the pest. This multi-targeted approach makes it more difficult for the nematode population to develop resistance through mutations, while also ensuring a more consistent and higher level of efficacy in the field.

220. (B) I only
Nematode effectors are highly specialized proteins that are synthesized primarily within the esophageal glands, not the cuticle. These molecules are injected into host tissues via the stylet to facilitate the parasitic process. The subventral glands are typically active during invasion, while the dorsal gland maintains the feeding site. Furthermore, effectors play a vital role in suppressing the plant's innate immune system, ensuring the nematode's survival within the host.

221. (A) Nematodes have evolved to secrete structural mimics of plant peptides to hijack host pathways.
Genomic and transcriptomic studies have revealed a fascinating example of molecular mimicry in plant-parasitic nematodes. Some secreted effectors are structural analogs of important plant regulatory proteins, such as CLE peptides. By producing these mimics, the nematode can hijack the plant's own signaling pathways to manipulate cell development and redirect nutrient flow toward the feeding site. This sophisticated strategy is a hallmark of

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the complex evolutionary interaction between nematodes and their hosts.

222. (C) Anti-nutritional proteins that inhibit gut proteases to impair digestion and cause stunting.
Proteinase inhibitors used in transgenic crops act as anti-nutritional factors. These proteins work by binding to and inactivating the digestive enzymes, particularly proteases, in the nematode's gut. This inhibition prevents the nematode from properly digesting the proteins it ingests from the plant tissues. The resulting deficiency in essential amino acids severely impairs the nematode's growth, development, and ability to reproduce, providing a significant level of host resistance.

223. (D) It caused severe groundwater contamination and was linked to male worker sterility.
DBCP was once a highly valued nematicide, but its use was globally restricted due to serious human health and environmental concerns. The chemical was found to be a persistent contaminant in groundwater, posing a long-term risk to water supplies. Furthermore, significant medical evidence linked exposure to the chemical in manufacturing plants to male sterility among workers. these findings led to the eventual withdrawal of the product from the agricultural market.

224. (C) Organophosphate binding to AChE is generally considered irreversible, whereas carbamate binding is often reversible.
While both organophosphates and carbamates target the enzyme acetylcholinesterase, they differ in the nature of their chemical binding. The phosphorylation of the enzyme by organophosphates is generally a stable and irreversible process, leading to permanent inhibition. In contrast, the carbamylation of the enzyme by carbamates is often a reversible reaction. This means that if the concentration of the chemical decreases, the enzyme can eventually regain its activity, allowing the pest to recover.

225. (B) It is a succinate dehydrogenase inhibitor (SDHI) that disrupts mitochondrial respiration in nematodes.
Fluopyram is a relatively new and highly effective nematicide that belongs to the SDHI chemical class. Its mode of action is specifically focused on the mitochondria of the target pests. By inhibiting the enzyme succinate dehydrogenase, the chemical prevents the normal flow of electrons in the respiratory chain, effectively shutting down cellular energy production. This targeted biochemical disruption leads to the rapid immobilization and death of the nematodes.

226. (D) It is highly sensitive to most chemical nematicides, completely ruling out any use in integrated management.
Purpureocillium lilacinum is a robust biological control agent that shows compatibility with several management practices. While some chemical pesticides can be harmful, this fungus often exhibits a degree of tolerance to many common nematicides and fertilizers. This flexibility allows it to be integrated into broader management programs, where both biological and chemical tools are used in a complementary manner to achieve more effective and sustainable control of nematode populations.

227. (A) They use a large buccal cavity armed with teeth to seize and swallow prey nematodes whole.
Mononchid nematodes are significant natural predators in the soil ecosystem. Their hunting strategy is purely physical and mechanical. They possess a large, heavily sclerotized buccal cavity, often equipped with one or more prominent mural teeth. This specialized anatomy allows them to firmly seize other soil organisms, including both beneficial and plant-parasitic nematodes, and either swallow them whole or use their teeth to rupture the prey's cuticle and consume the contents.

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228. (C) It restricts the diffusion of the fumigant gas through the soil pore spaces, leading to poor distribution and reduced efficacy.
The effectiveness of a volatile soil fumigant like 1,3-Dichloropropene depends on its ability to diffuse through the air-filled pores in the soil. When soil moisture levels are too high, many of these pores are filled with water, which significantly restricts the movement of the gaseous chemical. This results in poor distribution of the fumigant throughout the soil profile, leading to areas with insufficient concentrations to achieve a lethal dose for the nematodes.

229. (A) They can act as pre-infectional biochemical factors if they contain constitutive nematoxic or repellent compounds.
Pre-infectional biochemical resistance involves toxic or repellent compounds that are naturally present in the plant tissues before any nematode attack occurs. These constitutive chemicals can include various alkaloids, phenolics, or glycosides that are synthesized as part of the plant's normal metabolism. When a nematode attempts to infect the root, these pre-existing substances can immediately inhibit its movement, feeding, or penetration, providing an instant and effective layer of defense.

230. (A) I, II and IV
Resistance genes are powerful tools for managing major nematode pests in agriculture. The Mi gene in tomato provides broad resistance against three major species of root-knot nematodes. In potato, the H1 gene is a single dominant gene that confers high-level resistance specifically to the most common pathotypes of the potato cyst nematode, Globodera rostochiensis. Understanding the inheritance and specificity of these genes is essential for their effective use in breeding and management.

231. (B) Maintaining the population below ETL while maximizing net economic returns.
The ultimate goal of Integrated Nematode Management is not the total eradication of every nematode, which is often biologically impossible and economically unjustifiable. Instead, success is defined by keeping the pest population below the Economic Threshold Level. This ensures that the damage caused by the nematodes is minimal and that the financial investment in management practices leads to the highest possible net economic return for the farmer.

232. (C) Successive use may cause enhanced microbial degradation which reduces field efficacy.
Continuous reliance on the same non-fumigant nematicide over many years can lead to the development of enhanced microbial degradation. In this process, specialized soil microbes evolve to rapidly break down the chemical, using it as a source of nutrients. This results in the nematicide disappearing from the root zone much faster than intended, significantly reducing its persistence and field efficacy, and forcing farmers to seek alternative management strategies.

233. (D) Evaluation of scientific evidence to determine if a pest should be regulated and measures taken.
Pest Risk Analysis is a formal, science-based process utilized by plant protection organizations to determine the appropriate level of quarantine regulation. It involves evaluating all available scientific evidence regarding a specific pest's biology, potential for entry and establishment, and its likely economic and environmental impacts. The outcome of a PRA provides the technical and legal justification for implementing or maintaining import restrictions and other quarantine measures.

234. (A) Representative coverage to account for the aggregated distribution of nematodes.
Nematodes are rarely distributed evenly throughout an agricultural field; instead, they tend to occur in clusters or patches. Using a "W-pattern" or a stratified zigzag sampling strategy is essential because it ensures that cores are taken from many different parts of the field. This comprehensive coverage provides a much more accurate and representative estimate of the total nematode population than taking samples from a single area or along a straight line.

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235. (B) One should avoid sampling severely desiccated, dead plants or leaving samples in a hot vehicle.
Accurate nematode assay depends on the collection and handling of high-quality samples. One should avoid taking samples from plants that are already dead or severely desiccated, as the nematode populations in those areas may have already declined significantly. Furthermore, heat is lethal to many nematodes. Leaving samples in a hot vehicle can quickly kill the pests, leading to false-negative results or a severe underestimation of the actual soil population.

236. (B) ETL fluctuates based on the market value, cost of intervention, and environment.
The Economic Threshold Level is a dynamic value that changes according to several external factors. It is not a fixed biological constant. Instead, it fluctuates based on the current market value of the crop, the cost of the specific management intervention, and various environmental conditions that influence plant vigor and nematode activity. Managers must consider all these factors together to determine the most cost-effective time to initiate control measures.

281. (D) Combined use of compatible tactics where the effect is greater than their simple sum.
Synergism is a key concept in Integrated Nematode Management, referring to a positive interaction between different control methods. It occurs when two or more compatible tactics are used together and produce a combined management effect that is significantly greater than what would be expected from simply adding their individual effects. For example, some biological control agents may be more effective when applied to nematode populations that have been already stressed or weakened by sub-lethal cultural or chemical treatments.

282. (A) It impairs mobility and development without inhibiting acetylcholinesterase.
Fluensulfone is a modern nematicide that offers a novel biochemical approach to pest management. Its primary mechanism of action involves the rapid and significant impairment of the nematode's development and its ability to move through the soil. Crucially, this effect is achieved through a physiological pathway that does not involve the inhibition of the enzyme acetylcholinesterase. This distinction makes it an important tool for managing nematode populations that may have developed resistance to more traditional neurotoxic chemical treatments.

283. (B) Individual soil cores should be thoroughly and gently mixed together to form a representative composite sample before drawing a subsample.
Collecting a representative soil sample is essential for an accurate nematode diagnostic report. A single field sample should consist of multiple individual cores taken from across the entire area. Once collected, all these cores must be thoroughly but gently mixed together to create a single composite sample. This mixing process ensures that the subsample actually sent to the laboratory for analysis is a representative reflection of the average nematode population across the entire field or sampling unit.

284. (B) A waiting period of 2 to 3 weeks after incorporation is essential to allow for microbial decomposition before planting.
The effective use of oil cakes as soil amendments for nematode management requires careful timing. These organic materials are not immediately nematicidal upon application. Instead, they must undergo a process of microbial decomposition in the soil, which releases the active toxic byproducts like ammonia and organic acids. A waiting period of two to three weeks is essential to allow these levels to reach lethal concentrations and to ensure that any initial phytotoxic effects have dissipated before the crop is sown.

285. (A) Biological agents universally provide the exact same rapid, 100% knockdown effect as methyl bromide within 24 hours.
It is incorrect to characterize biological control agents as providing the same rapid and total knockdown effect as broad-spectrum chemical fumigants. The action of biological agents, such as beneficial fungi or bacteria, is typically much slower and more complex. They often require specific environmental conditions to establish and multiply before they can significantly impact the nematode population. Their value lies in providing sustained, long-term suppression and improved soil health rather than an immediate, total elimination of the pest.

286. (C) It is environmentally safe and provides season-long protection embedded in the seed.
Utilizing resistant plant varieties offers several distinct advantages in an integrated management program. Unlike chemical applications that may require multiple treatments and can have off-target effects, resistance is a biological trait that is built into the plant itself. This provides continuous, season-long protection against nematode invasion and damage. Furthermore, it is a highly environmentally safe approach, as it eliminates or significantly reduces the need for synthetic nematicide applications, protecting soil health and water quality.

287. (D) Biofilm colonization and metabolite secretion confuse host-finding and damage eggs.
Antagonistic rhizobacteria, such as Bacillus firmus, protect host plants through a combination of physical and chemical mechanisms. Once applied, these bacteria colonize the root surface, often forming a protective biofilm. During their growth, they secrete various metabolites and enzymes that can directly damage nematode eggs or interfere with the chemical signals the pest uses to find roots. This multi-faceted biological activity creates a hostile environment for nematodes in the rhizosphere, effectively reducing the success of their infection and reproduction.

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after field application is technically challenging, which has restricted their current role primarily to natural suppression rather than active commercial biopesticides.

245. (A) An official NPPO document verifying a shipment conforms to specific importing requirements.
International phytosanitary certification is an official process designed to facilitate the safe global trade of plants and plant products. The certificate is an official document issued by the National Plant Protection Organization of the exporting country. It confirms that the shipment has been thoroughly inspected and found to be free from regulated pests, ensuring that it complies with the specific phytosanitary import requirements of the destination nation.

246. (D) The Nilgiri and Kodaikanal hills of Tamil Nadu
In India, the Potato Cyst Nematode is subject to strict domestic quarantine measures. These regulations specifically restrict the movement of potato tubers and soil from the high-altitude regions of the Nilgiri and Kodaikanal hills in Tamil Nadu. Because these destructive pests are relatively confined to these cool, temperate areas, the quarantine is essential to prevent their spread into the major potato production zones in the northern plains and other parts of the country.

247. (B) It is applied primarily as a pre-plant soil fumigant via shank injection.
1,3-Dichloropropene is a powerful volatile chemical used primarily as a pre-plant soil fumigant. Its application involves the use of specialized equipment with metal shanks that inject the liquid chemical deep into the soil. Once in the soil, the chemical evaporates into a toxic gas that diffuses through the pore spaces. To ensure efficacy, it must be applied well before planting to allow the gas to eliminate nematodes and then dissipate.

248. (C) They disrupt the transmission of nerve impulses across the synapse by preventing the breakdown of the neurotransmitter acetylcholine.
Organophosphate and carbamate nematicides function by targeting the nervous system of the pest. They specifically inhibit the enzyme acetylcholinesterase, which is responsible for breaking down the neurotransmitter acetylcholine in the synaptic cleft. By preventing this breakdown, these chemicals cause a continuous and lethal over-stimulation of the nerves and muscles. This leads to the rapid paralysis of the nematode, preventing it from performing vital life functions like feeding and movement.

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249. (D) They act as powerful, broad-spectrum soil fumigants that sterilize the field.
Next-generation nematicides like Fluensulfone are distinctly different from traditional broad-spectrum soil fumigants. They are non-volatile chemicals that do not turn into gas or sterilize the entire soil profile. Instead, they represent a more targeted and environmentally friendly class of chemistry. They work through specific physiological pathways that inhibit nematode development and movement while offering a much safer profile for mammals and other non-target organisms in the agricultural environment.

250. (A) P-2, Q-1, R-4, S-3
Resistance genes are essential components of integrated management systems for various crops. The Mi-1.2 gene is widely used for root-knot nematode resistance in tomato, while the H1 gene specifically protects potatoes from Globodera rostochiensis. In sugarbeet, the Hs1pro-1 gene provides resistance against cyst nematodes, and the Rk gene is used in cowpea. Each of these genes provides a targeted and sustainable method for reducing damage caused by specific nematode species.

251. (B) EC is a liquid concentrate for water-mixing while GR is a dry solid for direct soil application.
Nematicides are formulated in various ways to suit different application needs. An Emulsifiable Concentrate (EC) is a liquid product that must be mixed with water before use, forming an emulsion for spraying or irrigation. A Granular (GR) formulation, on the other hand, consists of the active ingredient coated onto or mixed into dry, solid particles. Granules are designed for direct application to the soil surface, usually followed by mechanical incorporation or irrigation.

252. (B) It delivers the agent precisely to the active root zone where nematodes concentrate.
Chemigation through a drip irrigation system is a highly efficient method for applying nematicides. Because the water is delivered slowly and directly to the base of the plants, it carries

breeders to introgress the gene from wild potato species into modern, high-yielding cultivated varieties, providing effective protection against the potato cyst nematode.

296. (C) Solarization followed by bio-agent application often results in synergistic reduction.
The strategic integration of different management tactics is a hallmark of effective Integrated Nematode Management. A well-known synergistic interaction occurs when soil solarization is followed by the application of biological control agents. The solarization process initially reduces the population of many soil-borne pests and can weaken survivors. When beneficial microbes, such as antagonistic fungi or bacteria, are introduced into this partially sterilized soil, they can more easily establish and provide a sustained and deeper level of nematode suppression.

297. (D) RNAi permanently alters the fundamental genomic DNA sequence of the nematode.
It is important to distinguish the mechanism of RNA interference from other forms of genetic modification. RNAi is a post-transcriptional gene silencing process, meaning it acts by degrading the messenger RNA transcripts after they have been produced. Crucially, this mechanism does not involve any permanent changes or mutations to the fundamental genomic DNA sequence of the nematode. Once the double-stranded RNA trigger is removed, the nematode's ability to express the target gene will eventually return to its normal levels.

298. (A) Systematically unveiling parasitism genes and pathways to accelerate target discovery.
The sequencing of the Meloidogyne incognita genome was a major scientific achievement with profound practical implications for nematode management. By mapping the entire genetic blueprint of this highly destructive pest, researchers can systematically identify the specific genes and biochemical pathways that are essential for its ability to infect plants and survive. This detailed genetic information serves as an essential roadmap for the discovery and development of next-generation management tools, including targeted bionematicides and innovative gene-silencing strategies.

299. (B) PI-enzyme binding impairs protein digestion, causing starvation and stunting.
Transgenic crops engineered to express proteinase inhibitors provide resistance through a specific anti-nutritional pathway. When a sedentary endoparasitic nematode feeds on the roots of these plants, it ingests the inhibitory proteins along with its nutrient supply. These inhibitors then bind to the digestive proteases in the nematode's gut, preventing the breakdown and absorption of proteins. This results in severe amino acid starvation, which significantly stunts the development and reproductive capacity of the nematode, eventually leading to a reduction in damage.

300. (B) Heterodera avenae
The 'Molya' disease is a major agricultural concern in India, particularly in the northern wheat-growing states. It is caused by the cereal cyst nematode, scientifically known as Heterodera avenae. This pest specifically attacks the roots of wheat and barley, causing characteristic symptoms such as severe stunting, yellowing, and a bushy, reduced root system. The management of this destructive nematode relies on a combination of resistant varieties, crop rotation with non-host crops like mustard, and appropriate cultural practices.

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formation of large, multinucleate "giant cells." These specialized cells act as nutrient sinks, providing the sedentary nematode with the continuous food supply it needs.

260. (A) I, II, III, IV
Generating a transgenic plant with nematode resistance through HIGS follows a systematic sequence. First, transcriptomics is used to identify a gene essential for the nematode's survival. Next, a double-stranded RNA construct homologous to that gene is synthesized. This construct is then transformed into the host plant's genome. Finally, the transgenic plant expresses the dsRNA at the infection sites, where it is available to be ingested by the feeding nematode to trigger gene silencing.

261. (A) Ingested PIs interfere with gut enzymes causing amino acid deficiency and stunting.
Transgenic plants expressing proteinase inhibitors utilize an anti-nutritional defense strategy to manage nematodes. When a nematode feeds on the plant tissue, it ingests these inhibitory proteins, which then bind to and block the digestive enzymes in its gut. This inhibition prevents the nematode from properly breaking down and absorbing proteins from its diet, leading to a deficiency in essential amino acids. This nutritional stress results in the stunting, reduced development, and lower fecundity.

262. (D) Standard insecticidal Bt crops (like Bollgard cotton) automatically provide 100% control of all root-knot nematodes in the soil.
It is a common misconception that transgenic Bt crops designed to control insect pests also manage soil-borne nematodes. Standard insecticidal Bt proteins, such as those used against lepidopterans, are typically not toxic to nematodes. Successful nematode management requires the expression of specific Cry proteins, like Cry5B, which target nematode-specific intestinal receptors. Therefore, standard Bt crops do not provide any significant control of root-knot or other plant-parasitic nematodes unless they are specifically engineered for that purpose.

263. (B) Its well-annotated genome provides a blueprint for comparative and functional studies.
The completion of the Caenorhabditis elegans genome was a landmark event that significantly advanced the field of plant nematology. As a closely related but easily studied model organism, its well-annotated genetic blueprint serves as a vital reference. Researchers use comparative genomics to identify conserved biological pathways and unique parasitism-related genes in agricultural pests. This baseline knowledge is essential for accelerating the discovery of novel molecular targets for more effective and targeted nematode management strategies.

264. (C) Gene acquisition from microbes provided enzymes to degrade plant cell walls.
Horizontal gene transfer has been a foundational driver in the evolution of plant-parasitic nematodes. Genomic analysis shows that many of the enzymes these nematodes use to degrade plant cell walls, such as cellulases and pectinases, were originally acquired from soil-dwelling bacteria and fungi. This lateral acquisition of genes allowed the nematodes to develop the specialized tools necessary to invade root tissues and navigate through the plant cortex, a critical step in the development of parasitism.

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265. (D) Parasitism effectors are synthesized in esophageal glands and secreted via the stylet.
Esophageal gland effectors are the primary chemical tools that plant-parasitic nematodes use to manipulate their hosts. Transcriptomic studies have confirmed that these parasitism proteins are specifically synthesized within the dorsal and subventral glands. During the infection process, the nematode uses its hollow, needle-like stylet to inject these effectors directly into the host plant's cells. Once inside, these molecules orchestrate the complex physiological changes required for successful invasion, migration, and the establishment of feeding sites.

266. (A) J2s express genes for locomotion and migration while adults focus on site maintenance.
The transcriptomic profiles of different nematode life stages reflect their distinct biological needs. Infective second-stage juveniles are highly mobile and must find and invade a host root, so their transcriptomes show high expression of genes related to locomotion, sensory perception, and cell wall degradation. In contrast, the sedentary adult females have a fixed location and their gene expression shifts toward maintaining the specialized feeding site, nutrient uptake, and the massive production of eggs.

237. (A) The soil must be completely dry and powder-like for the heat to penetrate deeply.
Contrary to common assumptions, soil solarization is most effective when the soil is moist rather than dry. Adequate soil moisture is essential because it significantly improves the thermal conductivity of the soil, allowing heat to penetrate more deeply. Additionally, moisture makes nematodes and other soil-borne pests more metabolically active and sensitive to heat, ensuring a higher rate of mortality within the upper layers of the soil profile.

238. (C) To exploit the thermal tolerance differential between the plant tissue and the nematode.
Hot water treatment is a physical method for disinfesting planting materials that relies on a specific biological principle. It exploits the fact that many plant-parasitic nematodes have a lower thermal death point than the tissues of the host plant they infect. By heating the water to a precise temperature for a specific duration, the nematodes can be effectively killed while the bulbs, suckers, or tubers remain unharmed and viable for planting.

239. (D) It leads to anaerobiosis and the accumulation of lethal substances like hydrogen sulfide.
Flooding is an effective cultural practice for managing nematodes in crops like paddy. Prolonged submergence of the soil creates anaerobic conditions, as the water displaces oxygen in the soil pores. This anaerobiosis leads to the accumulation of various toxic metabolic byproducts, such as hydrogen sulfide, which are lethal to nematodes. This natural process helps significantly reduce the soil-borne population of pests like root-knot nematodes during the flooded period.

240. (A) Both A and R are true and R is the correct explanation of A.
Crop rotation is a highly effective management strategy, particularly for nematodes with a narrow host range like the potato cyst nematode. Because these pests are obligate parasites that require specific plants for nutrition, growing a non-host crop for several seasons effectively starves the population. This leads to a steady and predictable decline in the soil population density, making it a cornerstone of sustainable and long-term nematode management programs.

241. (B) As antagonistic crops that reduce populations through nematicidal allelochemical exudation.
Marigolds are utilized in integrated nematode management as antagonistic plants. They possess a unique biochemical defense mechanism where their roots synthesize and release allelochemicals, such as alpha-terthienyl, into the surrounding soil. These compounds are directly toxic to many species of plant-parasitic nematodes. By incorporating marigolds into a rotation or as an intercrop, farmers can naturally suppress nematode populations through this chemical interference in the rhizosphere.

242. (D) They improve soil properties and stimulate beneficial antagonistic microbes for suppression.
Organic amendments offer ecological benefits that distinguish them from traditional chemical fumigants. Beyond providing some level of direct pest suppression, they improve the physical and chemical properties of the soil, such as its structure and nutrient content. More importantly, they stimulate a diverse and active community of beneficial soil microorganisms. These natural antagonists provide long-term, sustained suppression of nematode populations, contributing to an overall healthier and more resilient soil ecosystem.

243. (A) They produce specialized three-dimensional adhesive nets or constricting rings to physically trap and consume motile nematodes.
Fungi in the genus Arthrobotrys are well-known biological control agents characterized by their predatory behavior. They possess the unique ability to develop specialized mycelial structures, such as adhesive networks or constricting rings, in response to the presence of nematodes. These traps physically seize motile nematodes as they move through the soil. Once captured, the fungus penetrates the host's body and consumes its internal contents, acting as an effective natural regulator.

244. (C) Challenges in mass rearing, formulation, and cannibalism limit commercial field application.
Although predatory nematodes like Mononchids are effective natural enemies, their large-scale commercial use remains limited. One of the primary hurdles is the difficulty in mass-producing these organisms in the laboratory, as many species have relatively slow reproductive rates and exhibit cannibalistic behavior. Additionally, ensuring their survival during formulation and

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274. (D) Its endospores are environmentally resistant, allowing excellent long-term persistence.
A significant advantage of utilizing Pasteuria penetrans in biological control is the remarkable resilience of its infective stage. The bacterium produces thick-walled endospores that are highly resistant to environmental stressors such as desiccation, extreme temperatures, and various soil chemicals. This environmental stability allows the spores to persist in the soil for many years, providing a continuous and long-term level of natural suppression that can eventually lead to the development of nematode-suppressive soils in agricultural fields.

275. (A) Silencing machinery processes dsRNA into siRNAs that degrade target endogenous mRNA.
The biological response of a nematode to ingesting double-stranded RNA is a highly coordinated intracellular process. Once inside the nematode's cells, the dsRNA molecule is recognized and cleaved by the enzyme DICER into short interfering RNAs. These siRNAs then integrate into a protein complex that guides the degradation of the matching messenger RNA. By eliminating the mRNA template, the cell can no longer produce the essential protein, resulting in the successful silencing of the target gene's function.

276. (C) As a science-based process involving Initiation, Risk Assessment, and Risk Management.
Pest Risk Analysis is a structured and internationally standardized process used to protect agricultural systems from exotic pests. It is divided into three distinct stages. Initiation involves identifying the pests or pathways that require analysis. Risk Assessment is the core scientific evaluation of the likelihood of entry, establishment, and spread, along with potential impacts. Finally, Risk Management involves identifying and selecting the most appropriate and effective measures to mitigate the identified risks through quarantine and regulation.

277. (A) They require soil moisture to reach the soil solution and be absorbed by host roots.
Systemic non-fumigant nematicides have different physical requirements for efficacy compared to volatile fumigants. Because they do not move as a gas, these chemicals must dissolve in the soil water to become biologically available. Adequate soil moisture is mandatory to allow the chemical to move through the soil solution and come into contact with the nematodes. Furthermore, moisture is essential for the plant roots to absorb and translocate the chemical throughout its tissues for systemic protection.

278. (D) Feeding site degradation leads to starvation, death, or an altered male-to-female ratio.
The resistance conferred by the Hs1pro-1 gene in sugarbeet specifically targets the development of the cyst nematode's feeding site. Rather than preventing the initial invasion, the gene triggers the premature degradation of the syncytium after it has formed. This loss of a nutritional base has severe consequences for the nematode, often leading to starvation and death. Furthermore, the lack of sufficient nutrients during development frequently forces surviving juveniles to become males, significantly reducing the reproductive potential of the population.

279. (B) Sequence data will help identify highly specific targets for precise bionematicides.
The integration of next-generation sequencing into nematode management is expected to revolutionize how pests are controlled. By providing a detailed map of the genetic diversity and essential biological pathways of various nematode species, NGS allows for the discovery of highly specific molecular targets. This information will facilitate the development of a new generation of precise bionematicides and gene-silencing strategies that are highly effective against target pests while having negligible effects on the broader environment and non-target organisms.

280. (A) I, II, III, IV
Executing a Host-Induced Gene Silencing strategy follows a logical, multi-step progression. The process begins with identifying an essential target gene through transcriptomic analysis of the nematode. Next, a specialized hairpin double-stranded RNA construct that is homologous to this target gene is designed and synthesized. This construct is then transformed into the plant genome using techniques like Agrobacterium-mediated transformation. Finally, the nematode ingests the plant-produced dsRNA while feeding, which triggers the internal silencing of the target gene.

NODIA

the dissolved chemical precisely into the active root zone or rhizosphere. This ensures that the active ingredient is concentrated exactly where the nematodes are feeding and reproducing, maximizing control efficacy while minimizing chemical waste and potential environmental exposure.

253. (A) High organic matter adsorbs chemical agents, reducing their availability to contact nematodes.
The chemical and physical properties of the soil can significantly influence the effectiveness of non-fumigant nematicides. Soil with high levels of organic matter can be particularly challenging because the organic particles have a high surface area and can strongly adsorb the active ingredients. This binding reduces the concentration of the chemical available in the soil solution to come into contact with the target nematodes, potentially leading to a decrease in management efficacy.

254. (C) They are synthesized de novo by the plant only after the nematode attempts penetration or infection.
Phytoalexins represent a dynamic and induced form of biochemical defense in plants. Unlike constitutive chemicals that are always present, phytoalexins are synthesized de novo only when the plant recognizes an infection or mechanical damage by a nematode. This targeted synthesis ensures that the plant conserves energy and resources, producing these potent antimicrobial and nematicidal compounds only when and where they are needed to inhibit the invading pest's progress.

255. (D) Its resistance is sensitive to temperature and often breaks down above 28-30°C.
The effectiveness of the Mi gene in tomato is notably constrained by environmental temperature. Research and field experience have shown that the resistance mechanism is thermally sensitive. When soil temperatures consistently rise above 28 to 30 degrees Celsius, the gene fails to trigger the protective hypersensitive response. Consequently, in hot climates or during peak summer months, tomato varieties carrying the Mi gene can become fully susceptible to root-knot nematode damage.

256. (C) It provides a targeted sequence-specific approach to silence genes without non-target harm.
RNA interference is an emerging biotechnological tool that offers unprecedented precision in nematode management. By utilizing the genetic sequence of the target pest, RNAi can be designed to silence only those genes that are essential to the nematode and unique to its species. This high degree of sequence specificity ensures that the management strategy has minimal impact on the host plant, humans, and other beneficial soil-dwelling organisms, providing a highly sustainable alternative.

257. (B) Engineering host plants to express dsRNA that triggers gene silencing upon ingestion.
Host-Induced Gene Silencing is a specific and innovative application of RNA interference technology. It involves genetically engineering a crop to produce double-stranded RNA molecules that match the genetic sequence of essential genes in a target pest. When the nematode feeds on the roots of these transgenic plants, it ingests the dsRNA, which then activates its internal gene silencing pathways. This process effectively disables the nematode's vital functions, providing the plant with built-in resistance.

258. (D) It was introgressed into cultivated sugarbeet from the wild relative Beta procumbens.
The Hs1pro-1 gene is a prime example of successful germplasm enhancement through the use of wild genetic resources. This critical resistance gene was originally identified in Beta procumbens, a wild relative of the cultivated sugarbeet. Through sophisticated breeding and introgression techniques, the gene was successfully moved into cultivated varieties, providing the first major genetic tool for managing the sugarbeet cyst nematode, a significant pest that previously lacked effective resistant cultivars.

259. (A) It induces the formation of multinucleate giant cells via repeated mitosis without cytokinesis.
The interaction between root-knot nematodes and susceptible plants is characterized by a sophisticated manipulation of host cell development. Once the nematode reaches its permanent feeding site, it injects effectors that trigger neighboring root cells to undergo repeated nuclear divisions. Crucially, these cells do not divide their cytoplasm, resulting in the

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288. (C) Specialized pests like Globodera rostochiensis are easier to manage with rotation.
The host range of a nematode species is a primary factor determining the feasibility and success of crop rotation as a management tactic. Specialized pests that have a very narrow range of host plants are much easier to control through rotation. By simply growing any crop that is not within that narrow range for a few years, the nematode population is deprived of its only source of nutrition, leading to a predictable and significant decline in the soil population density.

289. (B) Meloidogyne induces multinucleate giant cells while Globodera induces syncytia.
Meloidogyne and Globodera have evolved distinct strategies for creating the specialized feeding structures they need as sedentary endoparasites. Meloidogyne species use effectors to induce several neighboring cells to undergo multiple rounds of nuclear division without dividing their cytoplasm, resulting in giant cells. In contrast, Globodera species induce the formation of a syncytium, which is created by the selective dissolution of cell walls between adjacent cells, allowing their protoplasts to fuse into a single large, multinucleate feeding unit.

290. (C) A is true but R is false.
Strict domestic quarantine measures are indeed implemented in the Nilgiri Hills to restrict the movement of potato tubers and prevent the spread of the potato cyst nematode. However, the reason for this is not that the nematodes can swim long distances. In fact, nematodes are relatively immobile on their own, moving only a few meters per year through the soil. The primary risk for long-distance spread is the human-mediated movement of infested tubers, contaminated soil, and agricultural machinery.

291. (A) Potential establishment in local climates, economic impact, and entry pathways.
A comprehensive Pest Risk Analysis for a plant-parasitic nematode focuses on several critical factors. These include a detailed assessment of the likelihood that the nematode could establish itself given the local climate and available host plants. Furthermore, the analysis evaluates the potential economic damage the pest could cause to the nation's agriculture and identifies the most likely pathways, such as imported plant material or soil, through which the pest could enter the country.

292. (C) Regulatory pressure and environmental safety forced the shift to targeted chemistries.
The transition in the nematode management industry away from broad-spectrum fumigants is a result of multiple external pressures. Increasing regulatory restrictions, driven by concerns over the environmental impact and human health risks associated with traditional volatile chemicals, have been a major catalyst. This has forced researchers and chemical companies to focus on the development of more targeted and safer non-fumigant nematicides, which provide effective control with a significantly improved safety profile for workers and the environment.

293. (A) Precise application of water-soluble nematicides directly through irrigation systems.
Chemigation is a specialized and highly efficient technique in modern precision agriculture for the delivery of nematicides. It involves the careful injection of liquid or water-soluble pesticide formulations into an existing irrigation system. This method ensures that the chemical is delivered directly to the root zone of the crop along with the water. This targeted application provides uniform distribution of the nematicide throughout the soil profile, ensuring that the active ingredient reaches the target nematodes exactly where they are concentrated.

294. (D) Fermentation products of the soil bacterium Streptomyces avermitilis.
Abamectin is a powerful and widely used biological nematicide that is derived from natural sources. It is produced through the controlled fermentation of a specific soil-dwelling actinomycete known as Streptomyces avermitilis. During this process, the bacterium synthesizes several secondary metabolites called avermectins. Abamectin is a mixture of these compounds and is highly valued in agriculture for its ability to provide high levels of pest control at very low application rates while being a natural fermentation product.

295. (B) It exhibits single dominant gene inheritance, conferring high-level resistance.
The H1 gene in potato is a vital genetic resource that follows a simple and predictable inheritance pattern. It is characterized as a single dominant gene, which means that only one copy of the gene is required for the plant to express high levels of resistance. This simple genetic architecture has made it relatively straightforward for plant

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267. (B) The target should be essential for viability but highly divergent in non-target species.
Selecting an ideal molecular target for a new bionematicide requires careful consideration of both efficacy and environmental safety. The chosen gene or enzyme must perform a function that is absolutely critical for the nematode's survival or reproduction to ensure high potency. Simultaneously, the target must be structurally or genetically divergent from similar proteins in humans, beneficial insects, and the host plants themselves. this divergence is necessary to minimize the potential for harmful off-target effects.

268. (B) Asexual species show genomic complexity and expansions explaining their wide host range.
Genomic analysis of asexual root-knot nematodes, such as Meloidogyne incognita, has revealed a surprisingly complex and expanded genome. Despite the lack of sexual recombination, these species possess multiple copies of many genes, often through polyploidy. This genomic expansion is thought to provide the nematode with a large and diverse toolkit of parasitism-related proteins. This genetic flexibility may explain their remarkable ability to adapt to hundreds of different host plant species and thrive in varied agricultural environments.

269. (A) The complete repertoire of proteins and molecules secreted by a parasite to facilitate the infection and manipulation of its host.
The parasitome represents the full chemical arsenal that a nematode employs to interact with and exploit its host plant. It includes all the effectors, cell wall-degrading enzymes, and other bioactive molecules that are synthesized by the nematode and secreted into the rhizosphere or directly into the plant tissues. By characterizing the parasitome, researchers can identify the specific molecular mechanisms that drive parasitism, providing a foundation for developing targeted strategies to disrupt these essential processes.

270. (C) Soil fumigation use was phased out under the Montreal Protocol due to ozone depletion.
Methyl bromide was once a cornerstone of global nematode management, but its status was fundamentally changed by international environmental law. Scientific evidence identified it as a significant contributor to the depletion of the stratospheric ozone layer. Under the Montreal Protocol, an international treaty signed by most nations, the production and agricultural use of methyl bromide for soil fumigation were systematically phased out. This global regulatory action forced the agricultural sector to search for more sustainable management alternatives.

271. (D) It is the point where the cost of pest control equals the value of the yield saved by that control.
The Economic Threshold Level is a fundamental concept in decision-making within integrated pest management. Graphically and mathematically, it is defined as the specific pest population density where the financial cost of applying a control measure is exactly balanced by the value of the crop yield that the measure will save. Intervention at this threshold ensures that the management action is economically justified, preventing the population from reaching levels where significant net losses would occur.

NODIA

272. (C) They suppress nematodes by producing secondary metabolites and inducing host resistance.
Beneficial bacteria in the genus Pseudomonas act as potent biological control agents through several complex mechanisms. They do not typically hunt nematodes directly. Instead, they colonize the rhizosphere and produce various secondary metabolites and antibiotics that are toxic or repellent to nematodes. Furthermore, their presence on the root surface can trigger the plant's own systemic defense pathways, known as induced systemic resistance, which makes the host less susceptible to nematode invasion and damage.

273. (B) The crop must be left in the field permanently to continuously kill nematodes without any human intervention.
Trap crops are a specialized management tool that requires active human intervention and precise timing to be effective. While these plants are highly attractive to nematodes and allow initial penetration, they must not be left in the field permanently. If they are not removed or destroyed before the trapped nematodes can mature and reproduce, the trap crop will instead become a breeding ground, eventually increasing rather than decreasing the soil's nematode population.

CHAPTER 08

Interactions of Nematodes with Soil Organisms

2019

1. Which ecological interaction occurs when nematode presence benefits a secondary pathogen without reciprocal benefit?
(A) Mutualism
(B) Commensalism
(C) Antagonism
(D) Synergism

2003

2. What is the primary role of bacterivorous nematodes in the soil food web?
(A) Primary production
(B) Carbon fixation
(C) Pathogen suppression
(D) Nitrogen mineralization

2025

3. Which mechanism best explains how nematodes break plant genetic resistance to fungi?
(A) Physiological modification of host root exudates
(B) Production of fungicidal toxins
(C) Competitive exclusion of fungi
(D) Direct feeding on fungal hyphae

2018

4. Identify the INCORRECT statement regarding the Meloidogyne and Fusarium wilt disease complex.
(A) Nematodes induce mechanical wounding for fungal entry.
(B) Giant cells serve as rich nutrient sinks for the fungus.
(C) The interaction is strictly antagonistic.
(D) Nematode infection typically precedes fungal invasion.

2016

5. Which nematode species is the primary inciting agent of the "Black head" or "Toppling" disease of bananas in complex with fungi?
(A) Radopholus similis
(B) Globodera rostochiensis
(C) Xiphinema index
(D) Tylenchulus semipenetrans

2024

6. Which trap type is NOT typically formed by the nematophagous fungus Arthrobotrys?
(A) Adhesive networks
(B) Constricting rings
(C) Adhesive knobs
(D) Endospores

2014

7. Purpureocillium lilacinum is primarily recognized as a biocontrol agent targeting which nematode stage?
(A) Active, motile juveniles
(B) Eggs and sedentary females
(C) Non-feeding adult males
(D) Resistant dauer larvae

2018

8. Identify the correct pair of endoparasitic fungus and its primary infectious structure.
(A) Catenaria anguillulae - Adhesive knobs
(B) Arthrobotrys oligospora - Zoospores
(C) Hirsutella rhossiliensis - Adhesive spores
(D) Pochonia chlamydosporia - Constricting rings

2021

9. Which combination forms a recognized synergistic disease complex?
(A) Pratylenchus penetrans and Rhizobium leguminosarum
(B) Heterodera avenae and Pasteuria penetrans
(C) Xiphinema index and Fusarium oxysporum
(D) Meloidogyne incognita and Ralstonia solanacearum

2022

10. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Anguina tritici is required for the development of yellow ear rot (Tundu) disease in wheat.
Reason (R): Anguina tritici acts as a vector that

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transport the bacterium.
(D) The organisms compete for the same specialized seed nutrients.

2015

32. Photorhabdus bacteria are mutualistically associated with which nematode genus?
(A) Steinernema
(B) Heterorhabditis
(C) Mononchus
(D) Diplogaster

2021

33. The pathogenesis of Pasteuria penetrans is unique because it:
(A) Forms a germ tube that penetrates the host cuticle directly.
(B) Invades the host primarily through the internal digestive tract.
(C) Relies on a specific fungal intermediate stage for transmission.
(D) Replicates exclusively within the specialized host giant cells.

2009

34. Arbuscular Mycorrhizal Fungi (AMF) primarily improve host tolerance to nematodes by enhancing the uptake of which nutrient?
(A) Nitrogen
(B) Calcium
(C) Phosphorus
(D) Iron

2022

35. Interspecific competition between sedentary endoparasitic nematodes and AMF typically occurs for:
(A) Xylem vessels
(B) Leaf mesophyll
(C) Apical meristems
(D) Cortical root tissues

2024

36. When Meloidogyne incognita and Heterodera glycines co-infect a plant, what typically occurs?
(A) Complete elimination of Meloidogyne
(B) Enhanced reproduction of both species
(C) Competition leading to reduced population densities of one or both
(D) Hybridization between the two genera

2003

37. Which predatory nematode injects paralyzing toxins into its prey through a specialized stylet?
(A) Seinura
(B) Mononchus
(C) Diplogaster
(D) Xiphinema

2015

38. The nematode family Trichodoridae belongs to which taxonomic Order?
(A) Dorylaimida
(B) Tylenchida
(C) Rhabditida
(D) Triplonchida

2007

39. Arabis mosaic virus (ArMV) is primarily transmitted by:
(A) Xiphinema diversicaudatum
(B) Longidorus macrosoma
(C) Trichodorus viruliferus
(D) Paratrichodorus pachydermus

2011

40. Consider the following statements concerning Tobraviruses:
I. They are transmitted by Dorylaimida nematodes.
II. They are transmitted by Trichodoridae nematodes.
III. They include Tobacco rattle virus (TRV).
IV. They are retained in the odontostyle.
Which of the above statement(s) is/are correct?
(A) II and III
(B) I, III and IV
(C) II, III and IV
(D) I and IV

2025

41. In Longidorus species, where are virus particles specifically retained?
(A) The lining of the odontostyle
(B) The lining of the odontophore
(C) The intestinal lumen
(D) The reproductive tract

2014

42. How do the moulting process affect a nematode's ability to transmit viruses?
(A) It extends the viral retention time.
(B) It causes an immediate loss of infectivity.
(C) It facilitates viral multiplication.
(D) It permanently integrates the virus into the nematode genome.

2022

43. Secondary opportunistic rotting microorganisms primarily utilize plant-parasitic nematodes as:
(A) Sources of essential amino acids
(B) Mechanical facilitators providing entry

NODIA

2024

21. What happens to plant viruses retained within a nematode vector during the moulting process?
(A) They are lost with the shed exuviae.
(B) They multiply exponentially.
(C) They are incorporated into the new cuticle.
(D) They migrate to the nematode's reproductive tract.

2003

22. Nematodes acting as mechanical vectors for secondary opportunistic microorganisms primarily facilitate disease by:
(A) Suppressing the plant immune system through secreted effectors.
(B) Acting as obligate intermediate hosts for bacterial reproduction.
(C) Synthesizing volatile compounds that attract fungal spores.
(D) Providing entry wounds and damaged tissue for colonization.

2010

23. Which term describes the breakdown of host resistance to a fungal pathogen solely due to prior nematode infection?
(A) Synergism
(B) Predisposition
(C) Commensalism
(D) Mutualism

2008

24. Which group of nematodes contributes significantly to nitrogen mineralization by consuming soil bacteria?
(A) Plant-parasitic nematodes
(B) Entomopathogenic nematodes
(C) Bacterivorous nematodes
(D) Fungivorous nematodes

2017

25. The interaction between Meloidogyne and Fusarium oxysporum f. sp. vasinfectum on cotton is an example of:
(A) True antagonism
(B) Predation
(C) Competitive exclusion
(D) A synergistic disease complex

2006

26. In the Pratylenchus and Verticillium disease complex, how does the nematode primarily influence fungal pathogenesis?
(A) It alters root physiology and delays host defense responses.
(B) It acts as a specialized obligate biological transport vector.
(C) It provides a stable protective cyst for fungal spore survival.
(D) It actively feeds on beneficial antagonistic rhizosphere bacteria.

2013

27. Which trapping structure relies on cellular expansion triggered by nematode contact?
(A) Adhesive networks
(B) Constricting rings
(C) Non-constricting rings
(D) Adhesive branches

2003

28. Pochonia chlamydosporia reduces plant-parasitic nematode populations by:
(A) Predating on motile juveniles using adhesive spores.
(B) Producing toxic volatile organic compounds.
(C) Trapping adult males in mycelial networks.
(D) Parasitizing nematode eggs and sedentary females.

2008

29. Which endoparasitic fungus produces zoospores to infect motile nematodes?
(A) Catenaria anguillulae
(B) Hirsutella rhossiliensis
(C) Arthrobotrys dactyloides
(D) Monacrosporium cionopagum

2010

30. Consider the following statements regarding the Meloidogyne and Ralstonia disease complex:
I. Nematode infection always occurs post-bacterial colonization.
II. Nematode wounds facilitate bacterial entry into the vascular system.
III. Giant cells restrict bacterial multiplication.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) I and III
(C) II and III
(D) III

2008

31. The bacterium Rathayibacter tritici causes yellow ear rot. What is its relationship with Anguina tritici?
(A) The bacterium parasitizes the juvenile stage of the nematode.
(B) The nematode relies on the bacterium for its own reproduction.
(C) The nematode acts as an essential vector to

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carries Rathayibacter tritici cells to the wheat apex.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

11. The relationship between Steinernema species and Xenorhabdus bacteria is best classified as which of the following?
(A) Facultative parasitism
(B) Mutualistic symbiosis
(C) Competitive amensalism
(D) Obligate antagonism

2018

12. Pasteuria penetrans exhibits host specificity primarily during which stage of its life cycle?
(A) Germ tube penetration into the pseudocoelom
(B) Endospore attachment to the nematode cuticle
(C) Mycelial fragmentation inside the host
(D) Release of mature spores into the soil

2008

13. How do Arbuscular Mycorrhizal Fungi (AMF) typically enhance plant tolerance against plant-parasitic nematodes?
(A) By increasing root system vigor and nutrient uptake
(B) By secreting specialized soil-borne nematicidal exoenzymes
(C) By directly parasitizing and consuming nematode eggs
(D) By competing for specific viral transmission sites

2009

14. Which factor is the least relevant in the spatial competition between Glomus species and Meloidogyne species?
(A) Competition for root colonization sites
(B) Alteration of root exudate profiles
(C) Phloem sap flow rate
(D) Resource allocation in host cortical cells

2015

15. In concomitant infections of Meloidogyne and Heterodera, what is the most common interspecific interaction?
(A) Synergistic enhancement of both populations
(B) Mutualistic resource sharing
(C) Complete spatial segregation without competition
(D) Asymmetrical competition often favoring Meloidogyne

2012

16. Which of the following nematode genera is predatory and possesses a large buccal cavity with teeth?
(A) Pratylenchus
(B) Ditylenchus
(C) Mononchus
(D) Trichodorus

2013

17. To which taxonomic Order do the virus-vectoring nematodes Xiphinema and Longidorus belong?
(A) Tylenchida
(B) Dorylaimida
(C) Triplonchida
(D) Aphelenchida

NODIA

2006

18. Grapevine fanleaf virus (GFLV) is specifically transmitted by which nematode species?
(A) Longidorus elongatus
(B) Trichodorus primitivus
(C) Paratrichodorus minor
(D) Xiphinema index

2015

19. Tobraviruses are specifically transmitted by nematodes belonging to which family?
(A) Trichodoridae
(B) Longidoridae
(C) Heteroderidae
(D) Hoplolaimidae

2016

20. Match the virus-vectoring nematode genera in List I with their viral retention sites in List II:
List I: (Genera)
P. Xiphinema
Q. Longidorus
R. Trichodorus
S. Paratrichodorus
List II: (Retention Sites)
I. Odontostyle lining
II. Odontophore lining
III. Onchiostyle lining
IV. Pharynx lining
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-IV, R-I, S-II
(D) P-I, Q-III, R-II, S-IV

through wounds
(C) Biological vectors for internal reproduction
(D) Competitive antagonists against beneficial microbes

2002

44. Which interaction describes two nematode species competing for the same feeding site, resulting in mutual growth suppression?
(A) Amensalism
(B) Antagonism
(C) Competition
(D) Synergism

2019

45. Fungivorous nematodes contribute to nutrient mineralization by:
(A) Fixing atmospheric nitrogen.
(B) Solubilizing soil phosphorus directly.
(C) Synthesizing mycorrhizal networks.
(D) Consuming pathogenic fungi and releasing sequestered nitrogen.

2015

46. Genetic resistance to secondary soil pathogens is most commonly compromised by:
(A) Nematicidal applications
(B) Fungal endophyte colonization
(C) Decreased soil moisture
(D) Nematode-induced physiological changes and wounding

2023

47. The interaction between Meloidogyne and Fusarium oxysporum is best characterized as:
(A) Commensal
(B) Synergistic
(C) Antagonistic
(D) Parasitic

2010

48. Pratylenchus penetrans is notoriously involved in a disease complex with which fungal pathogen in potatoes?
(A) Rhizoctonia solani
(B) Phytophthora infestans
(C) Verticillium dahliae
(D) Pythium ultimum

2012

49. Which genus of nematophagous fungi is known for forming adhesive three-dimensional networks?
(A) Catenaria
(B) Pasteuria
(C) Purpureocillium
(D) Arthrobotrys

2008

50. Consider the following statements regarding nematode parasitic fungi:
I. Purpureocillium lilacinum infects eggs.
II. Hirsutella rhossiliensis is an endoparasite.
III. Pochonia chlamydosporia forms constricting rings.
IV. Monacrosporium relies on adhesive structures.
V. Catenaria anguillulae produces zoospores.
Which of the above statement(s) is/are correct?
(A) I, II, IV and V
(B) I, II and V
(C) II, III, IV and V
(D) I, III and IV

2022

51. Catenaria anguillulae is classified as an endoparasitic fungus primarily because it:
(A) Forms extensive external trap networks.
(B) Parasitizes only sedentary female nematodes.
(C) Reproduces sexually outside the host.
(D) Develops its vegetative structures entirely within the host body.

2022

52. The synergistic interaction between Meloidogyne and Ralstonia solanacearum leads to severe incidence of which disease?
(A) Root rot
(B) Bacterial wilt
(C) Powdery mildew
(D) Leaf spot

2016

53. In the Tundu disease complex, Anguina tritici juvenile stages carry the Rathayibacter tritici bacteria on their:
(A) Cuticle
(B) Intestinal microvilli
(C) Stylet lumen
(D) Reproductive organs

2024

54. The symbiotic bacteria Xenorhabdus and Photorhabdus reside in which part of the entomopathogenic nematode?
(A) Pseudocoelom
(B) Reproductive tract
(C) Intestine
(D) Pharyngeal glands

2023

55. What is the terminal stage of a Pasteuria penetrans infection in a nematode?
(A) Depletion of body contents and release of

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endospores
(B) Transition to a state of extreme nematode hypermotility
(C) Transformation into a secondary biological transport vector
(D) Immediate reversal of all previously occurring moulting processes

2025

56. Which process is NOT a mechanism by which AMF confers tolerance to nematode infection?
(A) Improved plant nutrition
(B) Altered root morphology
(C) Direct synthesis of nematode-specific toxins by the fungus
(D) Activation of plant defense responses

2003

57. Sedentary endoparasitic nematodes and AMF both require high amounts of host carbon. This relationship often results in:
(A) Spatial and nutritional competition
(B) Synergistic growth of both organisms
(C) Exclusion of the nematode from the xylem
(D) Enhanced nematode reproduction

2015

58. Concomitant infection of roots by two different plant-parasitic nematodes usually results in:
(A) Increased population densities for both species
(B) conversion of one species into a predator
(C) Immediate plant death before reproduction occurs
(D) Niche overlap and population reduction for one or both species

2021

59. Which predatory nematode utilizes a large, unarmed stoma to engulf prey whole or suck out their contents?
(A) Mononchus
(B) Seinura
(C) Diplogaster
(D) Xiphinema

2012

60. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Nematodes of the family Trichodoridae transmit Tobraviruses.
Reason (R): Tobraviruses are retained in the cuticular lining of the nematode's pharynx.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

61. Pea early-browning virus (PEBV) belongs to which viral genus?
(A) Nepovirus
(B) Tobravirus
(C) Cucumovirus
(D) Tospovirus

2004

62. Where do Nepoviruses typically attach within their specific vector nematodes?
(A) Intestinal wall
(B) Odontostyle and odontophore
(C) Pharyngeal bulb
(D) Amphidial pouch

2001

63. Which factor limits the retention time of plant viruses in nematode vectors?
(A) Nematode feeding frequency and moulting
(B) Viral replication rate inside the nematode
(C) Temperature of the upper canopy
(D) The size of the viral RNA genome

NODIA

2023

64. Nematodes facilitate root rots by acting as mechanical vectors. This means they:
(A) Multiply the pathogen internally within the salivary glands.
(B) Genetically alter the pathogen to achieve higher virulence.
(C) Create physical wounds that opportunistic microbes exploit.
(D) Ingest and protect the microbes in their gut indefinitely.

2010

65. When the presence of one soil organism inhibits the activity of a nematode without gaining any direct benefit, the interaction is called:
(A) Amensalism
(B) Mutualism
(C) Synergism
(D) Commensalism

2011

66. How do fungivorous nematodes primarily impact the soil food web?
(A) By directly transmitting several types of plant viruses
(B) By suppressing mycorrhizal networks in a

specific manner
(C) By competing with bacterivores for identical food sources
(D) By regulating fungal biomass and participating in nutrient cycling

2004

67. The phenomenon where a resistant plant cultivar becomes susceptible to a fungus following nematode infection is termed:
(A) Induced systemic resistance
(B) Nematode-induced predisposition
(C) Mutualistic breakdown
(D) Commensal synergism

2005

68. In the Meloidogyne-Fusarium complex, the severity of wilt disease is highest when:
(A) The fungus infects before the nematode.
(B) Only the fungus is present.
(C) The plant is grown in sterile soil.
(D) The nematode infects before the fungus.

2018

69. Which symptom is most characteristic of the Pratylenchus and Verticillium disease complex?
(A) Excessive root galling
(B) Premature plant senescence and severe wilting
(C) Yellow ear rot
(D) Hypertrophy of foliar tissues

2011

70. Match the nematophagous fungi in List I with their trapping mechanisms in List II:
List I: (Fungi)
P. Arthrobotrys dactyloides
Q. Monacrosporium ellipsosporum
R. Dactylella lobata
S. Arthrobotrys oligospora
List II: (Mechanisms)
I. Adhesive knobs
II. Constricting rings
III. Adhesive networks
IV. Non-constricting rings
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-IV, R-II, S-I
(D) P-II, Q-IV, R-I, S-III

2014

71. Which stage of Meloidogyne is highly susceptible to parasitism by Pochonia chlamydosporia?
(A) J2 in the soil
(B) Adult males
(C) Egg masses on the root surface
(D) J1 inside the egg before oviposition

2025

72. Hirsutella rhossiliensis infects nematodes using which specific structure?
(A) Zoospores
(B) Adhesive conidia
(C) Constricting rings
(D) Haustoria

2005

73. The interaction between Meloidogyne species and bacterial wilt (Ralstonia solanacearum) is prominent in which crop?
(A) Wheat
(B) Tomato
(C) Barley
(D) Apple

2003

74. Rathayibacter tritici utilizes Anguina tritici primarily to:
(A) Gain access to the plant root system directly from the soil.
(B) Be transported from the soil to the developing floral primordia.
(C) Overwinter inside the nematode's gut until the next season.
(D) Evade the activity of competing bacterial rhizosphere populations.

NODIA

2023

75. What induces the infectious juvenile (IJ) of Steinernema to release its symbiotic bacteria?
(A) Contact with plant root exudates
(B) Encystment in the soil
(C) High soil moisture levels
(D) Penetration into the insect hemocoel

2006

76. Which structural feature of Pasteuria penetrans facilitates its attachment to the nematode cuticle?
(A) Adhesive hyphal net
(B) Motile flagella
(C) Constricting ring cells
(D) Parasporal fibers on the endospore

2011

77. AMF colonization typically alters root exudates, which can lead to:
(A) Increased attraction of nematode infective juveniles
(B) Decreased attraction or repulsion of nematode juveniles
(C) Immediate death of all soil microflora

(D) Enhanced nematode moulting rates

2014

78. When AMF and sedentary nematodes occupy the same root system, what is the primary limiting resource?
(A) Photosynthetically derived carbon
(B) Atmospheric nitrogen
(C) Soil oxygen
(D) Root xylem sap

2002

79. In cases of concomitant infection by Root-knot and Cyst nematodes, competition often leads to:
(A) Extinction of both populations
(B) Fusion of their specialized feeding cells
(C) Cross-genus mating
(D) Spatial separation, with Root-knot nematodes occupying different root zones than Cyst nematodes

2006

80. Consider the following statements regarding predatory nematodes:
I. Mononchids possess a heavily cuticularized stoma with teeth.
II. Seinura uses a stylet to inject toxins.
III. Diplogasterids only feed on plant roots.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2014

81. Which nematode family includes vectors for Nepoviruses?
(A) Trichodoridae
(B) Heteroderidae
(C) Pratylenchidae
(D) Longidoridae

2025

82. Which of the following is a recognized Nepovirus transmitted by nematodes?
(A) Tobacco rattle virus
(B) Pea early-browning virus
(C) Cucumber mosaic virus
(D) Arabis mosaic virus

2003

83. Trichodorus and Paratrichodorus species are the exclusive vectors for which group of viruses?
(A) Tobraviruses
(B) Nepoviruses
(C) Potyviruses
(D) Luteoviruses

2004

84. In Trichodorus species, plant viruses are retained primarily on the cuticular lining of the:
(A) Odontostyle
(B) Pharynx and onchiostyle
(C) Intestine
(D) Spicules

2023

85. The acquisition access period (AAP) refers to the:
(A) Time required for a nematode to lose a virus during moulting
(B) Time taken for the virus to replicate inside the nematode
(C) Lifespan of the nematode vector
(D) Minimum feeding time required for a nematode to acquire a transmissible virus

2011

86. Which characteristic prevents nematode-transmitted viruses from being classified as persistent-propagative?
(A) They are retained through the moulting process.
(B) They circulate through the nematode's hemocoel.
(C) They require an insect intermediate host.
(D) They do not replicate within the nematode vector.

2013

87. An interaction where nematodes facilitate secondary fungal decay of storage roots is best described as:
(A) Predisposition
(B) Mechanical vectoring
(C) Commensalism
(D) Mutualism

2015

88. Nematodes that consume fungi but do not parasitize plants are known as:
(A) Omnivores
(B) Bacterivores
(C) Predators
(D) Fungivores

2012

89. The breakdown of plant genetic resistance to Fusarium wilt by Meloidogyne incognita is an example of:
(A) Amensalism
(B) Neutralism

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(C) Commensalism
(D) Disease synergism

2003

90. Consider the following statements regarding the Pratylenchus-Verticillium disease complex:
I. It is common in mint and potato.
II. Nematode feeding provides entry courts for the fungus.
III. The interaction decreases overall wilt severity.
IV. Pratylenchus is a migratory endoparasite.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and IV
(C) III
(D) III and IV

2014

91. The fungus Arthrobotrys oligospora transitions from saprophytic to predatory behavior primarily in response to:
(A) High levels of soil nitrogen
(B) Detection of nematode-specific cues (ascarosides) and low nutrients
(C) High soil moisture
(D) Increased root exudation of sugars

2022

92. Which biocontrol fungus is most commercially utilized for its ability to parasitize Meloidogyne eggs?
(A) Purpureocillium lilacinum
(B) Hirsutella rhossiliensis
(C) Arthrobotrys dactyloides
(D) Catenaria anguillulae

2002

93. Endoparasitic fungi that infect motile nematode stages typically initiate infection via:
(A) Adhesive conidia or zoospores
(B) Constricting rings
(C) Appressoria on eggs
(D) Haustoria into giant cells

2012

94. The combined infection of Meloidogyne and Ralstonia solanacearum results in:
(A) Significantly reduced bacterial colonization within host tissues.
(B) A shortened incubation period for bacterial wilt symptom expression.
(C) The systemic enhancement of host plant constitutive immunity.
(D) Complete exclusion of the nematode population from the roots.

2003

95. In the yellow ear rot disease of wheat, what structure of Anguina tritici carries the bacteria?
(A) The mature female cuticle
(B) The infective second-stage juvenile (J2) cuticle
(C) The eggshell
(D) The adult male spicules

NODIA

2008

96. Xenorhabdus species produce secondary metabolites inside the insect host primarily to:
(A) Attract other entomopathogenic nematodes to the site.
(B) Prevent putrefaction by inhibiting competing opportunistic microbes.
(C) Hasten the physiological moulting of the nematode vector.
(D) Provide structural support to the decaying insect candy.

2021

97. Which structural component of Pasteuria penetrans is responsible for its high host specificity?
(A) Sporangium
(B) Central core
(C) Exosporium/parasporal fibers
(D) Germ tube

2021

98. Which physiological change induced by AMF contributes most to plant tolerance against nematodes?
(A) Rapid depletion of host root carbohydrates.
(B) Upregulation of defense-related enzymes such as chitinases.
(C) Significant decrease in secondary lignin synthesis.
(D) Increased permeability of root tissue cell walls.

2024

99. The spatial competition between AMF and sedentary nematodes is most intense in which root tissue?
(A) Epidermis
(B) Xylem
(C) Phloem
(D) Cortex

2002

100. Match the nematode interaction concepts in List I with their definitions in List II:

List I: (Concepts)
P. Synergism
Q. Antagonism
R. Predisposition
S. Competition
List II: (Definitions)
1. Breakdown of plant resistance due to nematode infection
2. Both organisms suffer reduced fitness due to shared resources
3. One organism inhibits another without reciprocal benefit
4. Combined effect exceeds the sum of individual effects
(A) P-IV, Q-III, R-I, S-II
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-IV, R-II, S-I
(D) P-II, Q-I, R-IV, S-III

2016

101. During concomitant infection by Meloidogyne and Pratylenchus, what is a likely spatial outcome?
(A) Pratylenchus colonizes the vascular cylinder, displacing Meloidogyne.
(B) Meloidogyne induces galls in the vascular cylinder, while Pratylenchus creates lesions in the cortex.
(C) Both species share the identical giant cell syncytia.
(D) Pratylenchus feeds entirely ectoparasitically to avoid Meloidogyne.

2006

102. Which morphological feature distinguishes predatory Mononchid nematodes?
(A) A barrel-shaped stoma equipped with cuticular teeth
(B) A long, slender stylet
(C) A well-developed bursa
(D) Absence of a digestive tract

2011

103. The Order Triplonchida includes which virus-vectoring nematode family?
(A) Trichodoridae
(B) Longidoridae
(C) Xiphinematidae
(D) Hoplolaimidae

2022

104. Which Nepovirus is associated with Xiphinema americanum?
(A) Tomato ringspot virus (ToRSV)
(B) Grapevine fanleaf virus (GFLV)
(C) Arabis mosaic virus (ArMV)
(D) Pea early-browning virus (PEBV)

2014

105. Tobraviruses are characterized structurally by having:
(A) Isometric particles
(B) Enveloped, spherical particles
(C) Flexuous filamentous particles
(D) Rod-shaped, bipartite genome particles

2019

106. In the nematode vector Xiphinema index, the viral retention site is lined with:
(A) Cellulose
(B) Chitin
(C) Cuticle (carbohydrate-based)
(D) Peptidoglycan

2008

107. Loss of viral infectivity during the nematode moulting process is definitive proof that:
(A) Viruses are retained on shed cuticular linings.
(B) Viruses replicate internally in the intestine.
(C) Viruses cause lethal mutations in the host.
(D) Nematodes acquire lifelong immunity to viruses.

2009

108. Mechanical vectors differ from biological vectors primarily because mechanical vectors:
(A) Transmit pathogens purely through physical contamination or wounding
(B) Allow the pathogen to complete its life cycle internally
(C) Require a latent period before transmission
(D) Only transmit viruses, never bacteria

2019

109. Which interaction characterizes the relationship between plant roots and beneficial non-parasitic nematodes?
(A) Direct mutualism via carbon exchange
(B) Amensalism
(C) Obligate parasitism
(D) Indirect commensalism or mutualism via nutrient cycling

2018

110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Interspecific competition among plant-parasitic nematodes is common in agricultural soils.

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Reason (R): Different nematode species often have identical feeding site requirements and host ranges.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

111. Which primary mechanism explains how nematodes predispose plants to secondary soil pathogens?
(A) Production of viral particles
(B) Leakage of root exudates through mechanical and enzymatic wounding
(C) Depletion of soil nitrogen
(D) Competition for sunlight

2013

112. The presence of Meloidogyne often breaks down resistance to Fusarium wilt in which major crop?
(A) Maize
(B) Cotton
(C) Soybean
(D) Potato

2014

113. Pratylenchus species contribute to Verticillium wilt complexes primarily by:
(A) Inducing giant cells that feed the fungus
(B) Modifying the host physiology and creating entry courts
(C) Act as true biological vectors for the fungus
(D) Synthesizing nematicidal toxins

2011

114. Which generic group of nematophagous fungi captures nematodes using non-constricting rings?
(A) Dactylella
(B) Arthrobotrys
(C) Purpureocillium
(D) Pochonia

2001

115. What is the primary infection strategy of Pochonia chlamydosporia against Meloidogyne?
(A) It traps motile J2s in the soil.
(B) It forms endospores that attach to the nematode cuticle.
(C) It acts as a hyperparasite on other fungi.
(D) It colonizes the rhizosphere and penetrates nematode eggs enzymatically.

2022

116. Which fungus utilizes motile zoospores for finding and infecting nematodes?
(A) Catenaria anguillulae
(B) Arthrobotrys oligospora
(C) Hirsutella rhossiliensis
(D) Purpureocillium lilacinum

2015

117. The disease complex involving Meloidogyne and Ralstonia solanacearum is particularly devastating because:
(A) The nematode serves as a biological vector that multiplies bacteria.
(B) Giant cells provide a unique, nutrient-rich environment for bacteria.
(C) Nematode infection significantly accelerates bacterial wilt severity.
(D) Bacterial colonization provides a protective barrier for the nematode.

2022

118. Which statement regarding the Tundu disease complex is FALSE?
(A) It involves Anguina tritici.
(B) It involves Rathayibacter tritici.
(C) The interaction is an example of a viral vector mechanism.
(D) The nematode serves as a transport vector for the bacteria.

2007

119. In the mutualistic complex of entomopathogenic nematodes, what role does the bacterium play?
(A) It kills the insect host and predigests its tissues.
(B) It serves as a specialized transport mechanism to find hosts.
(C) It protects the juvenile from harmful soil predation.
(D) It provides essential structural support to the nematode cuticle.

2025

120. Consider the following statements regarding Pasteuria penetrans:
I. It is an obligate parasite of nematodes.
II. It is a Gram-positive bacterium.
III. It primarily infects nematode eggs.
IV. It produces endospores.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I and II
(C) II, III and IV
(D) III and IV

NODIA

(A) Synergistic
(B) Mutualistic
(C) Commensal
(D) Neutral

2002

142. Yellow ear rot in wheat relies on Anguina tritici carrying Rathayibacter tritici. This carriage occurs because:
(A) The bacteria naturally encyst within the nematode gut.
(B) The bacteria adhere to the nematode cuticle during the J2 stage.
(C) The nematode deliberately ingests the bacteria for its nutrition.
(D) The bacteria are vertically transmitted in the nematode eggs.

2002

143. Which bacterial genus forms a mutualistic symbiosis with Heterorhabditis nematodes?
(A) Xenorhabdus
(B) Pasteuria
(C) Bacillus
(D) Photorhabdus

2019

144. In the lifecycle of Pasteuria penetrans, what initiates the infection process?
(A) Ingestion of the endospore
(B) Attachment of the endospore to the cuticle of a moving juvenile
(C) Direct penetration of the eggshell by mycelia
(D) Germination of zoospores on the vulva

2004

145. AMF-mediated plant tolerance to nematodes is characterized by:
(A) Enhanced plant growth despite the presence and feeding of nematodes
(B) Complete prevention of nematode penetration into the host root system
(C) The systemic and permanent toxification of the invading nematode
(D) The large-scale attraction of specialized predatory soil nematodes

2001

146. Which morphological feature of AMF represents the primary site for nutrient exchange and spatial competition with nematode feeding sites?
(A) Vesicles
(B) Spores
(C) Extraradical hyphae
(D) Arbuscules

2009

147. During interspecific competition between Meloidogyne and Heterodera, population suppression of one species is most strongly linked to:
(A) Direct predation
(B) Competition for specific cellular feeding sites (syncytia vs. giant cells)
(C) Viral transmission
(D) Production of nematicidal toxins

2023

148. Which group of predatory nematodes possesses a functional stylet used to pierce and consume prey?
(A) Mononchids
(B) Diplogasterids
(C) Aphelenchids
(D) Seinurids

2011

149. The taxonomic Family Longidoridae is distinguished from Trichodoridae by having:
(A) A curved onchiostyle
(B) A long, hollow axial odontostyle
(C) A complete lack of males
(D) Obligate endoparasitic habits

2025

150. Consider the following statements regarding Nepoviruses:
I. They have spherical (isometric) particles.
II. They are transmitted by Trichodorus.
III. They include Grapevine fanleaf virus.
IV. They are transmitted by Xiphinema.
V. They are retained in the odontostyle or odontophore.
Which of the above statement(s) is/are INCORRECT?
(A) II
(B) I and III
(C) II and V
(D) I, III and IV

2018

151. Which vector-virus combination is correct?
(A) Longidorus - Tobraviruses
(B) Trichodorus - Nepoviruses
(C) Xiphinema - Nepoviruses
(D) Paratrichodorus - Luteoviruses

2008

152. In Paratrichodorus species, the virus retention site specifically aligns with the:
(A) Entire length of the internal nematode intestine.

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2016

131. Nematodes acting as mechanical vectors for soft-rot bacteria typically:
(A) Facilitate pathogen entry via stylet penetration and tissue maceration
(B) Induce genetic changes in the bacteria
(C) Disseminate the bacteria through active internal circulation
(D) Provide an essential nutrient for bacterial survival

2023

132. Which of the following is an example of an antagonistic ecological interaction in the rhizosphere?
(A) Nematode-trapping fungi capturing root-knot nematodes
(B) Nematodes disseminating beneficial rhizobia
(C) Meloidogyne and Fusarium enhancing wilt symptoms
(D) AMF improving host tolerance

2022

133. The primary ecological function of fungivorous nematodes like Aphelenchus avenae is to:
(A) Control the population of pathogenic and saprophytic fungi
(B) Act as obligate vectors for fungal viruses
(C) Synthesize essential amino acids for plant roots
(D) Induce galling in weed species

2025

134. Nematode-induced predisposition is most accurately measured by observing:
(A) The increase in nematode reproduction within roots during fungal co-infection.
(B) Development of severe symptoms in a resistant cultivar when nematodes are present.
(C) The rate of fungal sporulation and mycelial growth on laboratory agar plates.
(D) The suppression of both pathogens through competitive ecological exclusion.

2012

135. In the disease complex of root-knot nematodes and Fusarium wilt, which physiological alteration is critical?
(A) Giant cells acting as nutrient-rich sinks for fungal hyphae
(B) Increased lignification of host xylem vessels
(C) Synthesis of specific nematicidal exudates by the fungus
(D) The complete and permanent closure of plant stomata

2015

136. Which nematode species is NOT typically implicated in a Verticillium wilt disease complex?
(A) Pratylenchus penetrans
(B) Pratylenchus neglectus
(C) Heterodera avenae
(D) Pratylenchus thornei

2013

137. The formation of constricting rings by Arthrobotrys dactyloides is an example of:
(A) Passive trapping
(B) Endoparasitism
(C) Egg parasitism
(D) Active trapping

2024

138. Which fungal enzyme is considered crucial for the penetration of nematode eggshells by Purpureocillium lilacinum?
(A) Cellulase
(B) Ligninase
(C) Chitinase
(D) Amylase

NODIA

2019

139. Hirsutella rhossiliensis differs from Arthrobotrys oligospora because it:
(A) Forms constricting rings
(B) Paralyzes prey using zoospores
(C) Exclusively attacks nematode eggs
(D) Is a strict endoparasite utilizing adhesive spores

2005

140. Match the nematode genera in List I with their viral associations in List II:
List I: (Genera)
P. Xiphinema
Q. Trichodorus
R. Paratrichodorus
S. Longidorus
List II: (Viruses)
I. Pea early-browning virus (PEBV)
II. Grapevine fanleaf virus (GFLV)
III. Tomato black ring virus (TBRV)
IV. Tobacco rattle virus (TRV)
(A) P-II, Q-IV, R-I, S-III
(B) P-III, Q-I, R-IV, S-II
(C) P-IV, Q-II, R-III, S-I
(D) P-I, Q-III, R-II, S-IV

2018

141. The interaction between Meloidogyne incognita and Ralstonia solanacearum in tomato is best described as:

2006

121. Mycorrhiza-mediated tolerance to nematodes is most effective when:
(A) Nematodes infect before the AMF establishes.
(B) AMF establishes in the roots prior to nematode infection.
(C) The plant is grown under severe phosphorus deficiency.
(D) The AMF acts as a direct parasite of the nematode.

2019

122. Which ecological interaction is characterized by Rhizobium leguminosarum providing nitrogen to a legume while Meloidogyne inhibits its nodulation?
(A) Mutualism
(B) Commensalism
(C) Antagonism
(D) Synergism

2018

123. When two nematode species share the same root but occupy different tissues (e.g., cortex vs. vascular cylinder), this is called:
(A) Niche partitioning
(B) Competitive exclusion
(C) Synergistic enhancement
(D) Amensalism

2023

124. Predatory nematodes belonging to the genus Seinura differ from Mononchids primarily because Seinura:
(A) Use a stylet to pierce prey and inject paralyzing secretions
(B) Possess a large buccal cavity with teeth
(C) Feed exclusively on plant cells when prey is scarce
(D) Belong to the order Triplonchida

2007

125. Which characteristic distinguishes the Order Dorylaimida from Triplonchida in the context of virus-vectoring nematodes?
(A) Dorylaimida possess an odontostyle; Triplonchida possess an onchiostyle.
(B) Dorylaimida transmit Tobraviruses; Triplonchida transmit Nepoviruses.
(C) Dorylaimida lack a stylet entirely.
(D) Triplonchida are exclusively endoparasitic.

2006

126. Transmission of Strawberry latent ringspot virus (SLRSV) is associated with which nematode genus?
(A) Xiphinema
(B) Longidorus
(C) Trichodorus
(D) Paratrichodorus

2025

127. Which nematode genus is known for transmitting the Tobacco rattle virus (TRV)?
(A) Xiphinema
(B) Longidorus
(C) Trichodorus
(D) Globodera

2013

128. Functional anatomy indicates that in Longidorus, viruses are retained specifically in the:
(A) The lining of the odontostyle
(B) The lining of the odontophore
(C) Esophageal bulb lining
(D) Cuticle of the amphids

2022

129. The inoculation threshold period for a virus-vectoring nematode is defined as the:
(A) Maximum time a virus remains infective in the soil.
(B) Time required for the nematode to reach the adult stage.
(C) Viral replication time within the internal nematode gut.
(D) Minimum feeding time required to transmit the virus.

2022

130. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plant viruses transmitted by nematodes are generally lost during the moulting process.
Reason (R): The viruses are retained on the cuticular lining of the feeding apparatus, which is shed during moulting.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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(B) Cuticular lining of the internal pharyngeal tract.
(C) Secretions found within the amphidial pouch area.
(D) Structure associated with the stylet knobs only.

2015

153. What dictates the duration of viral retention in a non-moulting adult vector nematode?
(A) The ambient soil temperature
(B) The specific binding affinity between the viral coat protein and the nematode cuticular lining
(C) The reproduction rate of the virus in the nematode gut
(D) The concentration of root exudates

2011

154. Nematode wounds facilitate the entry of opportunistic rotting microorganisms. This relationship is best termed:
(A) Obligate mutualism
(B) Physiological predisposition
(C) Mechanical facilitation
(D) Genetic transformation

2025

155. Which ecological interaction results in a neutral outcome for one organism and a detrimental outcome for the other?
(A) Commensalism
(B) Parasitism
(C) Mutualism
(D) Amensalism

2008

156. Bacterivorous nematodes primarily aid in plant nutrition by:
(A) Fixing nitrogen from the atmosphere
(B) Grazing on bacteria and excreting excess nitrogen as ammonia
(C) Solubilizing organic phosphorus
(D) Protecting roots from pathogenic fungi

2004

157. The breakdown of genetic resistance in tomato to Fusarium wilt due to Root-knot nematode infection is an example of:
(A) Antagonism
(B) Nematode-induced predisposition
(C) Competitive exclusion
(D) Neutralism

2019

158. In the Meloidogyne and Fusarium wilt disease complex, the fungal pathogen often rapidly colonizes which nematode-induced structures?
(A) Syncytia
(B) Giant cells
(C) Cyst walls
(D) Egg masses

2004

159. The synergistic interaction between Pratylenchus and Verticillium dahliae typically leads to:
(A) Early dying syndrome in potatoes
(B) Specialized root knot disease
(C) Yellow ear rot in wheat
(D) Destructive pine wilt disease

2006

160. Select the correct sequence of events during nematode infection by Pasteuria penetrans:
(A) Endospore attachment, germ tube penetration, vegetative mycelial growth, sporulation
(B) Vegetative mycelial growth, endospore attachment, sporulation, germ tube penetration
(C) Germ tube penetration, sporulation, endospore attachment, vegetative mycelial growth
(D) Sporulation, germ tube penetration, vegetative mycelial growth, endospore attachment

2021

161. Arthrobotrys oligospora relies primarily on which trapping mechanism?
(A) Constricting rings
(B) Adhesive three-dimensional networks
(C) Non-constricting rings
(D) Adhesive spores

2015

162. Which biocontrol agent primarily parasitizes sedentary females and eggs of cyst and root-knot nematodes?
(A) Arthrobotrys dactyloides
(B) Catenaria anguillulae
(C) Pochonia chlamydosporia
(D) Monacrosporium ellipsosporum

2017

163. The infectious stage of the endoparasitic fungus Catenaria anguillulae is the:
(A) Conidium
(B) Ascospore
(C) Zoospore

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(D) Basidiospore

2005

164. The co-infection of tomato roots by Meloidogyne and Ralstonia solanacearum typically results in:
(A) Enhanced nematode reproduction and reduced wilt
(B) Accelerated and more severe bacterial wilt symptoms
(C) Complete competitive exclusion of the bacterium
(D) No observable change in disease severity

2008

165. Anguina tritici juvenile stages (J2) transmit Rathayibacter tritici by carrying the bacterial cells:
(A) Inside their digestive tract
(B) In their reproductive organs
(C) Adhered securely to their external cuticle
(D) Within specialized viral retention sites

2014

166. What provides the nutritional source for Steinernema nematodes developing inside an insect host?
(A) Living host insect hemocytes
(B) The host insect gut lining
(C) Tissues digested by Xenorhabdus bacteria
(D) Soil organic matter in the insect

2012

167. Following the attachment of Pasteuria penetrans endospores, what occurs next?
(A) Immediate death of the nematode
(B) Penetration of the cuticle via a germ tube
(C) Shedding of the cuticle to remove the spores
(D) Division of the endospore on the surface

2015

168. How do Arbuscular Mycorrhizal Fungi (AMF) structurally compete with endoparasitic nematodes?
(A) By physically wrapping around the nematode bodies
(B) By colonizing cortical cells required for feeding sites
(C) By replacing the host vascular system entirely
(D) By forming specialized constricting traps

2008

169. What is a common outcome when Meloidogyne and Glomus (AMF) species co-occur on a host plant?
(A) Complete elimination of the nematode
(B) Enhanced plant tolerance to the nematode damage
(C) Nematode-induced death of the mycorrhizae
(D) Transformation of AMF into a parasite

2013

170. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Interspecific competition between Meloidogyne and Heterodera often results in niche partitioning.
Reason (R): Both genera require identical giant cell feeding structures in the exact same root tissues.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

171. Which predatory nematode genus is known for having a heavily sclerotized buccal cavity equipped with a large dorsal tooth?
(A) Seinura
(B) Mononchus
(C) Xiphinema
(D) Longidorus

2012

172. The order Dorylaimida includes which two virus-vectoring genera?
(A) Xiphinema and Longidorus
(B) Trichodorus and Paratrichodorus
(C) Meloidogyne and Heterodera
(D) Pratylenchus and Radopholus

2008

173. Nepoviruses are characterized by their viral particle morphology, which is:
(A) Isometric (spherical)
(B) Rigid rods
(C) Flexuous threads
(D) Enveloped bacilliform

2007

174. Which combination of virus and vector is correctly matched?
(A) Tobacco rattle virus (TRV) - Trichodorus
(B) Grapevine fanleaf virus (GFLV) - Paratrichodorus
(C) Arabis mosaic virus (ArMV) - Longidorus
(D) Pea early-browning virus (PEBV) - Xiphinema

NODIA

2012

175. In the functional anatomy of Longidorus, where are viral particles specifically found attached?
(A) The inner surface of the odontostyle
(B) The odontophore
(C) The esophageal bulb lining
(D) The intestinal microvilli

2019

176. Which factor determines the loss of viral infectivity in nematodes after moulting?
(A) Degradation of the virus by digestive enzymes
(B) Shedding of the cuticular lining where the virus is retained
(C) Viral replication cycle completion
(D) Depletion of plant sap in the gut

2025

177. Nematodes functioning as mechanical vectors for secondary opportunistic fungi are most accurately described as:
(A) Direct biological hosts for the fungi
(B) Agents that create physical pathways for fungal infection through wounding
(C) Synthesizers of fungal growth hormones
(D) Primary pathogens suppressing the immune system

2015

178. Commensalism in the rhizosphere occurs when:
(A) Both organisms benefit.
(B) One organism benefits while the other is unaffected.
(C) Both organisms are harmed.
(D) One organism is harmed while the other is unaffected.

2003

179. The role of non-parasitic nematodes in nutrient mineralization is primarily achieved through:
(A) Direct decomposition of organic matter
(B) Feeding on primary decomposers like bacteria and fungi
(C) Symbiosis with nitrogen-fixing bacteria
(D) Photosynthetic carbon fixation

2006

180. Match the disease complex in List I with the typical nematode involved in List II:
List I: (Disease Complex)
P. Fusarium wilt
Q. Verticillium wilt
R. Bacterial wilt
S. Yellow ear rot
List II: (Nematode)
1. Anguina tritici
2. Meloidogyne incognita
3. Pratylenchus penetrans
4. Meloidogyne javanica
(A) P-II, Q-III, R-IV, S-I
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-I, R-IV, S-II
(D) P-IV, Q-III, R-II, S-I

2012

181. What is the fundamental mechanism behind nematode-induced predisposition?
(A) Alteration of physiology and compromise of defense barriers.
(B) Neutralization of the rhizosphere soil pH levels.
(C) Complete consumption of competing soil microbes.
(D) Genetic mutation of the host plant genome.

2012

182. A synergistic relationship between Meloidogyne and Fusarium is characterized by:
(A) Less severe symptoms than either pathogen alone
(B) More severe symptoms than the sum of their individual effects
(C) Competitive exclusion of the fungus
(D) Direct nematode feeding on fungal mycelia

2008

183. In the Pratylenchus and Verticillium disease complex, which type of nematode behavior primarily facilitates the interaction?
(A) Migratory endoparasitism causing extensive cortical necrosis
(B) Sedentary endoparasitism
(C) Ectoparasitic feeding on root hairs
(D) Predatory feeding on other nematodes

2018

184. The trap formation mechanism in Arthrobotrys dactyloides involves:
(A) A three-celled ring that inflates rapidly upon stimulation
(B) A single hyphal branch that secretes adhesive
(C) Adhesive conidia that attach directly to the cuticle
(D) Haustoria that penetrate intact eggs

2025

185. Which of the following is an egg-parasitizing fungus?
(A) Monacrosporium ellipsosporum
(B) Arthrobotrys oligospora
(C) Catenaria anguillulae

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(D) Purpureocillium lilacinum

2005

186. Which endoparasitic fungus utilizes adhesive conidia to infect motile nematodes?
(A) Catenaria anguillulae
(B) Pochonia chlamydosporia
(C) Dactylella lobata
(D) Hirsutella rhossiliensis

2016

187. Which crop is a common host for the synergistic complex between Meloidogyne and the bacterial wilt pathogen Ralstonia solanacearum?
(A) Potato
(B) Tomato
(C) Tobacco
(D) All of the above are susceptible hosts

2025

188. In the Tundu disease complex, what ensures that the bacteria reach the floral primordia of wheat?
(A) Active motility of the bacteria through the xylem
(B) Carriage on the cuticle of actively migrating Anguina tritici juveniles
(C) Fungal hyphal transport
(D) Rain splash and wind dispersion

2009

189. Consider the following statements concerning entomopathogenic nematodes (EPNs):
I. Steinernema associates with Xenorhabdus.
II. Heterorhabditis associates with Photorhabdus.
III. EPNs are obligate plant parasites.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and III
(C) I and II
(D) I, II and III

2022

190. Arrange the stages of an AMF-nematode interaction leading to plant tolerance:
I. AMF colonization of root cortex
II. Nematode penetration of root
III. Enhanced plant phosphorus uptake
IV. Mitigation of nematode-induced stress
(A) I, III, II, IV
(B) II, I, IV, III
(C) I, II, III, IV
(D) III, I, II, IV

2024

191. Pasteuria penetrans pathogenesis is severely hindered if:
(A) The nematode is a sedentary adult female before attachment occurs
(B) The soil is completely saturated
(C) The nematode cuticle lacks specific recognition receptors for the endospore
(D) Both A and C

2003

192. Which AMF genus is most frequently cited in studies mediating plant tolerance to root-knot nematodes?
(A) Glomus (Rhizophagus)
(B) Gigaspora
(C) Acaulospora
(D) Scutellospora

NODIA

2019

193. Spatial competition between AMF and sedentary nematodes primarily involves limited space in the:
(A) Epidermis
(B) Root cap
(C) Endodermis
(D) Root cortex

2014

194. Interspecific competition among plant-parasitic nematodes (e.g., Root-knot vs. Lesion nematodes) typically results in:
(A) Asymmetrical reduction in the population of one species
(B) Synergistic disease expression
(C) Mutualistic co-feeding
(D) Enhanced reproduction for both

2005

195. Which statement accurately describes a predatory nematode of the genus Diplogaster?
(A) It possesses a small stoma and often feeds on bacteria as well as nematodes.
(B) It has a heavily sclerotized buccal cavity equipped with multiple dorsal teeth.
(C) It paralyzes its prey using a specialized hollow stylet for toxin injection.
(D) It traps passing nematodes using specialized internal constricting ring structures.

2023

196. The family Trichodoridae is characterized taxonomically by:
(A) A curved onchiostyle
(B) A straight, hollow odontostyle
(C) A solid, curved onchiostyle

(D) The absence of a stylet

2013

197. Which specific Nepovirus is transmitted by Xiphinema index?
(A) Grapevine fanleaf virus
(B) Tomato ringspot virus
(C) Tobacco ringspot virus
(D) Arabis mosaic virus

2015

198. Tobraviruses are transmitted exclusively by members of which nematode family?
(A) Longidoridae
(B) Trichodoridae
(C) Xiphinematidae
(D) Tylenchulidae

2004

199. Functional anatomy reveals that in Xiphinema, viral particles are retained in the:
(A) Odontophore lining and esophageal bulb
(B) Onchiostyle lining
(C) Odontstyle lining
(D) Intestinal epithelium

2019

200. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Nematode-transmitted viruses are considered non-persistent or semi-persistent.
Reason (R): The viruses replicate actively within the nematode's digestive tract over its entire lifespan.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

201. Which term describes the minimum time a nematode must feed on a healthy plant to successfully transmit a virus?
(A) Inoculation access period (IAP)
(B) Acquisition access period (AAP)
(C) Latent period
(D) Retention period

2009

202. The presence of secondary opportunistic rotting microorganisms in nematode-damaged tissues is a consequence of:
(A) Nematode-induced mutualism
(B) Mechanical vectoring and tissue maceration by nematodes
(C) Specific viral transmission
(D) Fungal predatory traps

2005

203. Which interaction implies that two nematode populations compete for a limited root resource, causing mutual suppression?
(A) Commensalism
(B) Antagonism
(C) Competition
(D) Neutralism

2005

204. By grazing on microbial biomass, bacterivorous and fungivorous nematodes directly influence:
(A) Plant phototropism
(B) Aerial viral transmission
(C) Stomatal closure
(D) The carbon-to-nitrogen (C:N) ratio and nutrient mineralization in soil

2016

205. Nematode-induced predisposition is fundamentally a disruption of:
(A) Genetic resistance and physical/chemical barriers to secondary pathogens
(B) Nematode reproductive cycles
(C) Fungal sporulation rates
(D) Mycorrhizal networks

2006

206. A key physiological change in giant cells that favors Fusarium oxysporum colonization is:
(A) High accumulation of nutrients and specialized carbohydrates
(B) Increased lignification
(C) Depletion of amino acids
(D) Production of phytoalexins

2021

207. Which characteristic makes Pratylenchus species highly effective at inciting disease complexes with root-infecting fungi?
(A) Their destructive migratory endoparasitic feeding habit
(B) Their primarily sedentary endoparasitic feeding nature
(C) Their unique ability to form specialized protective cysts
(D) Their possession of large, sclerotized cuticular teeth

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2017

208. Monacrosporium typically traps nematodes using:
(A) Adhesive branches or knobs
(B) Constricting rings
(C) Endospores
(D) Zoospores

2014

209. Pochonia chlamydosporia reduces nematode populations primarily by:
(A) Digesting adult males
(B) Enzymatically penetrating and digesting eggs
(C) Trapping motile J2s in constricting rings
(D) Releasing systemic toxins into the plant

2012

210. Match the nematode type in List I with its ecological role in List II:
List I: (Nematode Type)
P. Bacterivore
Q. Fungivore
R. Predator
S. Plant-parasite
List II: (Ecological Role)
1. Solubilizes nitrogen from bacterial biomass
2. Grazes on hyphae, regulating fungal growth
3. Feeds on other nematodes, providing biocontrol
4. Consumes root cytoplasm, acting as primary pest
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-IV, R-I, S-II
(D) P-IV, Q-III, R-II, S-I

2007

211. Catenaria anguillulae represents which category of nematophagous fungi?
(A) Trap-forming predators
(B) Egg parasites
(C) Endoparasites infecting motile stages
(D) Toxin-producing antagonists

2006

212. In the synergistic complex between Meloidogyne and Ralstonia solanacearum, what is a primary role of the nematode?
(A) Creating mechanical wounds and altering root physiology for bacterial entry
(B) Producing antibiotics
(C) Serving as an obligate internal host for the bacteria
(D) Suppressing competing fungi

2004

213. Anguina tritici and Rathayibacter tritici together cause:
(A) Ear cockle and yellow ear rot (Tundu)
(B) Root knot and bacterial wilt
(C) Lesion and Verticillium wilt
(D) Cyst and Fusarium wilt

2004

214. The mutualism between entomopathogenic nematodes and their bacteria relies on the bacteria's ability to:
(A) Form protective cysts
(B) Synthesize nematicidal toxins
(C) Produce toxins that kill the insect and enzymes that break down its tissues
(D) Photosynthesize within the insect

2022

215. Pasteuria penetrans pathogenesis begins when:
(A) A nematode ingests an endospore
(B) An endospore adheres to the cuticle of a susceptible nematode
(C) The soil pH drops below 5.0
(D) A zoospore encysts on the nematode tail

2023

216. How does AMF colonization typically alter the host root system to affect nematode invasion?
(A) It directly parasitizes the invading juveniles.
(B) It causes increased lignification and altered root exudation patterns.
(C) It eliminates the root cortex entirely.
(D) It converts roots into storage tubers.

2003

217. Spatial competition between Glomus spp. and Meloidogyne occurs because both require access to:
(A) The root cortex for arbuscule and giant cell formation
(B) The root epidermis
(C) The apical meristem
(D) The root cap

2024

218. When Meloidogyne incognita and Pratylenchus penetrans co-infect a root, what mechanism drives their competition?
(A) Pratylenchus causes cortical necrosis, destroying the resources needed for giant cells.
(B) Meloidogyne juveniles physically attack the migratory Pratylenchus population.
(C) Both species compete for the exact same viral particles for successful reproduction.

NODIA

(D) They cross-breed within the root tissue, resulting in sterile hybrid offspring.

2024

219. Which structure allows Mononchids to effectively act as predatory nematodes?
(A) A long hollow stylet
(B) Adhesive knobs
(C) A heavily cuticularized stoma with a large dorsal tooth
(D) A constricting ring

2011

220. The nematode family Longidoridae belongs to which taxonomic Order?
(A) Triplonchida
(B) Dorylaimida
(C) Tylenchida
(D) Rhabditida

2016

221. Which genus is NOT classified under the virus-vectoring family Trichodoridae?
(A) Trichodorus
(B) Paratrichodorus
(C) Monotrichodorus
(D) Xiphinema

2006

222. The transmission dynamics of Nepoviruses by Xiphinema species require that the viral particles attach to the:
(A) Odontophore lining
(B) Esophageal bulb lining
(C) Onchiostyle lining
(D) Intestinal wall

2022

223. Consider the following statements about Tobraviruses:
I. They are transmitted by Trichodorus.
II. They possess rigid rod-shaped particles.
III. They are retained in the onchiostyle lining.
IV. They are lost during moulting.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I, II and IV
(C) I, II, III and IV
(D) II, III and IV

2003

224. In the context of virus transmission, functional anatomy refers to:
(A) The physical location where a virus is specifically retained within the nematode's feeding apparatus
(B) The genetic sequence of the viral coat protein
(C) The reproductive capacity of the nematode
(D) The size of the host plant's xylem vessels

2021

225. Why is virus infectivity lost during nematode moulting?
(A) Viruses are destroyed by moult-inducing hormones.
(B) The cuticular lining of the feeding apparatus, where viruses are retained, is shed.
(C) The nematode stops feeding permanently after the final stage of moulting.
(D) The virus integrates into the nematode's DNA during the moulting process.

2009

226. Consider the following statements about mechanical vectors:
I. Nematodes facilitate secondary bacterial infections.
II. The pathogens reproduce actively inside the nematode gut.
III. Tissue maceration by nematodes aids opportunistic microbes.
Which of the above statement(s) is/are correct?
(A) I
(B) I and III
(C) II and III
(D) I, II and III

2006

227. An interaction where one species relies entirely on another to complete its life cycle is termed:
(A) Obligate mutualism / Parasitism
(B) Commensalism
(C) Amensalism
(D) Neutralism

2001

228. Nematodes that feed exclusively on bacteria contribute to nutrient cycling primarily by:
(A) Sequestering carbon in their cuticles
(B) Producing oxygen
(C) Fixing atmospheric nitrogen
(D) Excreting excess mineral nitrogen (ammonium)

2006

229. The concept of "breakdown of genetic resistance" implies that:
(A) The plant's resistance genes are deleted from its genome.
(B) Nematode infection alters host physiology, making a normally resistant plant susceptible to a secondary pathogen.

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viruliferous nematode to infect a healthy plant
(C) The temperature required for viral replication
(D) The time taken for the nematode to moult

2009

272. Mechanical vectoring by nematodes primarily facilitates disease by:
(A) Creating wounds that serve as entry portals for secondary opportunistic pathogens
(B) Actively suppressing the host's genetic resistance pathways
(C) Serving as biological incubators for pathogen replication
(D) Releasing systemic toxins that wilt the plant

2023

273. The relationship between a plant and a beneficial bacterivorous nematode is best described as:
(A) Indirect mutualism via nutrient cycling
(B) Direct mutualism
(C) Antagonism
(D) Parasitism

2005

274. Which process most directly contributes to the breakdown of genetic resistance to Fusarium wilt in root-knot nematode infected plants?
(A) Formation of nutrient-rich giant cells that the fungus exploits
(B) Phytoalexin synthesis
(C) Lignification of the root cortex
(D) Direct nematode predation on the fungus

2021

275. Synergistic disease complexes involving plant-parasitic nematodes and fungi generally result in:
(A) Disease severity greater than the sum of the individual pathogens' effects
(B) Disease severity equal to the most virulent pathogen
(C) A reduction in overall disease severity
(D) Mutual exclusion of both pathogens

2010

276. Which nematode is notoriously involved in a disease complex with Verticillium dahliae in potato (Potato Early Dying)?
(A) Globodera pallida
(B) Meloidogyne chitwoodi
(C) Pratylenchus penetrans
(D) Ditylenchus destructor

2021

277. Arthrobotrys oligospora uses which specialized structure to trap nematodes?
(A) Adhesive networks
(B) Adhesive knobs
(C) Constricting rings
(D) Non-constricting rings

2010

278. Which statement best describes the action of Pochonia chlamydosporia?
(A) It forms constricting rings to trap motile juveniles.
(B) It parasitizes eggs and sedentary females of cyst and root-knot nematodes.
(C) It infects nematodes via motile zoospores.
(D) It is an obligate bacterial parasite.

2014

279. Catenaria anguillulae is an endoparasitic fungus that infects its nematode host primarily via:
(A) Zoospores that encyst on body orifices
(B) Adhesive conidia
(C) Constricting rings
(D) Appressoria formed on the egg surface

NODIA

2015

280. Match the specific virus in List I with its corresponding vector genus in List II:
List I: (Virus)
P. Tobacco rattle virus
Q. Grapevine fanleaf virus
R. Tomato black ring virus
S. Pea early-browning virus
List II: (Vector Genus)
1. Trichodorus
2. Xiphinema
3. Longidorus
4. Paratrichodorus
(A) P-I, Q-II, R-III, S-IV
(B) P-IV, Q-III, R-II, S-I
(C) P-II, Q-I, R-IV, S-III
(D) P-I, Q-IV, R-II, S-III

2019

281. The synergistic interaction between Meloidogyne and Ralstonia solanacearum is highly destructive because the nematode:
(A) Provides entry courts and modifies host tissues, rendering resistant cultivars susceptible.
(B) Feeds exclusively on the bacteria, causing them to mutate.
(C) Transmits the bacteria inside its eggs.
(D) Secretes antibiotics that kill competing beneficial microbes.

S. Constricting ring trapper

List II: (Specific Fungus)

1. Catenaria anguillulae
2. Pochonia chlamydosporia
3. Arthrobotrys oligospora
4. Arthrobotrys dactyloides

(A) P-II, Q-I, R-III, S-IV
(B) P-I, Q-II, R-IV, S-III
(C) P-III, Q-IV, R-I, S-II
(D) P-IV, Q-III, R-II, S-I

2005

241. Arbuscular Mycorrhizal Fungi (AMF) confer tolerance to nematodes largely through:
(A) Enhanced plant vigor and altered root exudation
(B) Direct parasitism of the nematode
(C) Synthesis of viral particles
(D) Competitive exclusion from the xylem

2023

242. Spatial competition between AMF (e.g., Glomus) and Meloidogyne occurs because both require access to:
(A) The root cortex for arbuscule and giant cell formation
(B) The root epidermis
(C) The apical meristem
(D) The root cap

2005

243. During concomitant infection, what is the most typical competitive outcome between Meloidogyne and Heterodera?
(A) Both populations crash due to hyperparasitism.
(B) They hybridize.
(C) Meloidogyne often suppresses Heterodera due to faster giant cell establishment.
(D) They share the same feeding syncytium.

2018

244. To which Order do the predatory nematodes of the genus Seinura belong?
(A) Mononchida
(B) Aphelenchida
(C) Dorylaimida
(D) Triplonchida

2005

245. Virus-vectoring nematodes in the Order Dorylaimida possess:
(A) An odontostyle
(B) An onchiostyle
(C) No stylet
(D) A stomatostylet

2015

246. The nematode Ditylenchus dipsaci is known to act as a mechanical vector for which bacterial pathogen causing "Cauoliflower disease" in strawberries?
(A) Rathayibacter tritici
(B) Ralstonia solanacearum
(C) Rhodococcus fascians
(D) Agrobacterium tumefaciens

2008

247. The virus group Tobravirus is specifically vectored by which family of nematodes?
(A) Longidoridae
(B) Trichodoridae
(C) Heteroderidae
(D) Aphelenchoididae

2025

248. In Longidorus nematodes, viral particles are specifically retained on the lining of the:
(A) Odontostyle
(B) Odontophore
(C) Intestine
(D) Esophageal bulb

NODIA

2005

249. The process by which a nematode loses its ability to transmit a virus because it sheds its cuticular feeding apparatus lining is known as:
(A) Senescence
(B) Moulting
(C) Encystment
(D) Diapause

2023

250. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Mechanical vectors transmit secondary rotting microbes by providing physical entry courts.
Reason (R): The rotting microbes actively reproduce within the nematode's salivary glands.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

251. An interaction where one species produces a substance toxic to another without gaining direct benefit is called:
(A) Commensalism

(C) The secondary pathogen mutates rapidly in the presence of nematodes.
(D) The nematode injects functional resistance genes into the plant.

2023

230. Arrange the sequence of virus transmission by a vector nematode:
I. Feeding on an infected plant
II. Retention of viral particles in the feeding apparatus
III. Migration to a healthy plant
IV. Inoculation via feeding
(A) II, I, IV, III
(B) I, II, III, IV
(C) I, III, II, IV
(D) III, IV, I, II

2024

231. The disease complex involving Root-knot nematodes and Fusarium oxysporum is a classic example of:
(A) True antagonism
(B) Synergism
(C) Commensalism
(D) Predation

2005

232. Pratylenchus species increase the severity of Verticillium wilt by:
(A) Providing systemic protection to the fungus
(B) Acting as vectors and causing extensive root necrosis that facilitates fungal entry
(C) Modifying the leaf stomata
(D) Reproducing exclusively within fungal hyphae

2021

233. Arthrobotrys dactyloides is characterized by its ability to capture nematodes using:
(A) Adhesive networks
(B) Constricting rings
(C) Adhesive spores
(D) Zoospores

2019

234. Purpureocillium lilacinum is a highly effective biocontrol agent primarily because it:
(A) Rapidly colonizes and destroys nematode eggs
(B) Forms large constricting rings
(C) Acts as an obligate endoparasite of motile J2s
(D) Synthesizes potent nematicidal fumigants

2005

235. The primary mode of infection for Hirsutella rhossiliensis involves:
(A) Zoospore encystment
(B) Adhesive conidia adhering to the passing nematode cuticle
(C) Constricting rings
(D) Appressoria penetrating eggshells

2009

236. Atkinson (1892) originally described the "Cotton Wilt" complex by observing that Meloidogyne infection:
(A) Decreased the reproductive rate of Fusarium.
(B) Accelerated and increased the severity of fungal symptoms.
(C) Had no measurable effect on the fungal pathogen.
(D) Prevented fungal spores from germinating.

2009

237. The physical association between Anguina tritici and Rathayibacter tritici occurs primarily on the:
(A) Cuticular surface of the second-stage juvenile (J2)
(B) Internal lining of the intestine
(C) Surface of the egg
(D) Reproductive spicules of the male

2011

238. In the Steinernema-Xenorhabdus complex, what is the role of the infective juvenile (IJ)?
(A) It acts as a protective vehicle to search for and penetrate an insect host.
(B) It provides structural support to the bacteria.
(C) It paralyzes the insect using cuticular teeth.
(D) It absorbs nutrients from plant roots to feed the bacteria.

2014

239. The host specificity of Pasteuria penetrans is dictated by:
(A) Specific attachment of parasporal fibers to receptors on the nematode cuticle
(B) The temperature of the soil
(C) The size of the nematode's buccal cavity
(D) The plant host species

2025

240. Match the nematode-fungus interaction in List I with the specific fungus in List II:
List I: (Interaction Type)
P. Egg parasite
Q. Endoparasite (zoospores)
R. Adhesive network trapper

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2016

261. The specific symbiosis between Heterorhabditis and Photorhabdus ensures that the nematode:
(A) Has a predigested insect food source free of competing opportunistic microbes
(B) Can photosynthesize in the soil
(C) Is resistant to plant defense mechanisms
(D) Can directly infect plant roots

2015

262. In the life cycle of Pasteuria penetrans, what happens immediately after the endospore attaches to the nematode cuticle?
(A) The nematode sheds its cuticle.
(B) A germ tube penetrates the cuticle into the pseudocoelom.
(C) The spore divides externally to form a network.
(D) The nematode undergoes rapid reproduction.

2011

263. Plant tolerance to nematodes mediated by AMF (e.g., Glomus) is often attributed to:
(A) Complete eradication of the nematode population
(B) Improved host phosphorus nutrition and overall vigor
(C) AMF predating on nematode eggs
(D) AMF physically blocking nematode stylet penetration

2014

264. What happens when AMF and endoparasitic nematodes compete for the same root spatial resources?
(A) Nematodes typically enhance AMF colonization.
(B) Colonization by AMF often restricts the space available for nematode feeding site development.
(C) The root cortex disintegrates completely.
(D) Both organisms form a mutualistic hybrid structure.

2002

265. During concomitant infection by Root-knot (Meloidogyne) and Cyst (Heterodera) nematodes, competition is primarily for:
(A) Epidermal feeding sites
(B) Access to the soil surface
(C) Vascular tissue to establish distinct specialized feeding cells
(D) Fungal partners

2019

266. Predatory nematodes belonging to the genus Mononchus are easily identified by their:
(A) Large, barrel-shaped stoma with one or more prominent teeth
(B) Long, flexible stylet
(C) Small, unarmed stoma
(D) Ability to form constricting rings

2017

267. The nematode Order Triplonchida is characterized by the presence of an onchiostyle and includes which virus-vectoring family?
(A) Longidoridae
(B) Trichodoridae
(C) Xiphinematidae
(D) Hoplolaimidae

2010

268. Which nematode acts as a vector for the Arabis mosaic virus (ArMV)?
(A) Xiphinema diversicaudatum
(B) Longidorus elongatus
(C) Trichodorus primitivus
(D) Paratrichodorus minor

2001

269. Tobraviruses, such as Tobacco rattle virus (TRV), are exclusively transmitted by:
(A) Xiphinema species
(B) Longidorus species
(C) Trichodorus and Paratrichodorus species
(D) Meloidogyne species

NODIA

2022

270. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The retention site for Nepoviruses in Xiphinema is the lining of the odontophore.
Reason (R): Xiphinema sheds the lining of the odontophore during moulting, resulting in the loss of viral infectivity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

271. What does the term "inoculation threshold" refer to in nematode virus transmission?
(A) The minimum number of viral particles needed to infect the nematode
(B) The minimum feeding time required by a

9. (D) Meloidogyne incognita and Ralstonia solanacearum
The interaction between Meloidogyne incognita and Ralstonia solanacearum represents a classic synergistic disease complex. The nematode provides essential mechanical entry wounds and alters host physiology, which significantly accelerates the colonization of the vascular system by the bacterial wilt pathogen. This interaction often leads to the breakdown of bacterial wilt resistance in crops like tomato and tobacco, causing severe yield losses.

10. (A) Both A and R are true and R is the correct explanation of A.
Tundu disease, or yellow ear rot of wheat, requires a specific interaction between the bacterium Rathayibacter tritici and the nematode Anguina tritici. The bacterium is non-motile and cannot reach the floral primordia independently. The nematode acts as an essential transport vector, carrying the bacterial cells on its cuticle to the growing point of the wheat plant, thus enabling disease development.

11. (B) Mutualistic symbiosis
The relationship between Steinernema nematodes and Xenorhabdus bacteria is an obligate mutualistic symbiosis. The nematode serves as a mobile vehicle that carries the bacteria into the insect host's hemocoel. In return, the bacteria release toxins that kill the insect and produce enzymes that break down its tissues into a nutrient-rich soup, which the nematode requires for growth and reproduction.

12. (B) Endospore attachment to the nematode cuticle
Pasteuria penetrans exhibits high host specificity during the initial attachment of its endospores to the nematode's cuticle. This process depends on specific molecular recognition between receptors on the nematode surface and the parasporal fibers of the bacterial endospore. If the endospore fails to adhere securely to the cuticle of a moving juvenile, the infection cycle cannot proceed, regardless of environmental conditions.

13. (A) By increasing root system vigor and nutrient uptake
Arbuscular Mycorrhizal Fungi enhance plant tolerance to nematodes by improving overall root health and nutrient acquisition, particularly phosphorus. By establishing a symbiotic relationship, these fungi increase the plant's biomass and vigor, allowing the host to compensate for the damage caused by nematode feeding. Additionally, mycorrhizal colonization can lead to physiological changes that make the root environment less favorable for nematodes.

14. (C) Phloem sap flow rate
Spatial competition between Glomus species and Meloidogyne primarily occurs within the root cortex, where both organisms establish specialized structures. They compete for colonization sites, available space, and photosynthetically derived carbon. While the alteration of root exudates and resource allocation are critical factors in this interaction, the phloem sap flow rate is generally considered the least relevant to their direct spatial competition.

15. (D) Asymmetrical competition often favoring Meloidogyne
When Meloidogyne and Heterodera co-infect the same host, they often engage in asymmetrical competition for feeding sites in the vascular cylinder. Meloidogyne species frequently gain a competitive advantage by establishing giant cells more rapidly, which can lead to the suppression of the Heterodera population. This interaction is driven by niche overlap, as both genera require similar specialized host tissues for successful reproduction.

16. (C) Mononchus
Mononchus is a well-known genus of predatory nematodes characterized by a large, heavily cuticularized buccal cavity. This stoma is typically equipped with one or more prominent dorsal teeth, which the nematode uses to grasp and puncture its prey. Mononchids are active soil predators that consume other nematodes whole or suck out their internal contents, playing a role in regulating soil populations.

17. (B) Dorylaimida
The virus-vectoring nematode genera Xiphinema and Longidorus belong to the taxonomic Order Dorylaimida. These nematodes are characterized by the presence of an odontostyle, a specialized hollow spear used for feeding on plant roots. Members of this order are the only known vectors for Nepoviruses, which they retain on the cuticular lining of their feeding apparatus and transmit during subsequent feeding.

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2013

282. Anguina tritici physically transports Rathayibacter tritici on its cuticle. This specific type of carriage is crucial for causing:
(A) Potato early dying
(B) Bacterial wilt
(C) Root knot
(D) Yellow ear rot (Tundu)

2025

283. In the mutualistic relationship between Steinernema and Xenorhabdus, the nematode provides the bacteria with:
(A) A safe harbor from soil antagonists and delivery into the insect hemocoel
(B) Essential carbon derived from plant roots
(C) Toxins to paralyze the insect
(D) Oxygen for aerobic respiration

2005

284. Pasteuria penetrans is categorized as an obligate parasite. This means it:
(A) Requires a living nematode host to complete its life cycle and reproduce
(B) Can survive indefinitely as a saprophyte in the soil
(C) Parasitizes only plant roots
(D) Must alternate between fungal and nematode hosts

2017

285. How does the presence of Arbuscular Mycorrhizal Fungi (AMF) generally affect the damage caused by plant-parasitic nematodes?
(A) It decreases the damage by enhancing plant tolerance and compensating for root loss.
(B) It increases the damage by attracting more nematodes.
(C) It has no measurable effect on plant health.
(D) It kills the nematodes on contact.

2018

286. Competition for spatial resources between AMF and sedentary endoparasitic nematodes occurs primarily in the:
(A) Phloem
(B) Root cortex
(C) Epidermis
(D) Root cortex

2016

287. When Meloidogyne and Heterodera co-infect a plant, what is a primary cause of their interspecific competition?
(A) They both attempt to establish their specialized feeding cells (giant cells and syncytia, respectively) in the vascular cylinder.
(B) They actively prey on each other's juveniles.
(C) They compete for the exact same viral vectors.
(D) They cross-mate, producing sterile hybrids.

2011

288. Which characteristic defines the predatory nematode genus Seinura?
(A) A hollow stylet used to inject paralyzing toxins into prey
(B) A large, heavily cuticularized stoma with a single large tooth
(C) An unarmed stoma used to engulf prey whole
(D) The formation of constricting rings

2011

289. The nematode families Longidoridae and Trichodoridae are classified under which respective Orders?
(A) Dorylaimida and Triplonchida
(B) Triplonchida and Dorylaimida
(C) Tylenchida and Rhabditida
(D) Rhabditida and Tylenchida

NODIA

2022

290. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Trichodorus and Paratrichodorus specifically transmit Tobraviruses.
Reason (R): These nematodes belong to the family Longidoridae, which is adapted for viral transmission.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

291. Which of the following viruses is a Tobravirus transmitted by nematodes?
(A) Pea early-browning virus
(B) Arabis mosaic virus
(C) Grapevine fanleaf virus
(D) Tomato ringspot virus

2019

292. Which nematode genus in the Dorylaimida is a recognized vector for the "Artichoke yellow ringspot virus"?
(A) Longidorus

(B) Mutualism
(C) Antagonism / Amensalism
(D) Synergism

2011

252. How do fungivorous nematodes interact with mycorrhizal fungi in the soil?
(A) They act as obligate mutualists for AMF spore germination.
(B) They can enhance or suppress AMF colonization depending on grazing intensity.
(C) They exclusively parasitize the AMF arbuscules.
(D) They have no interaction with AMF.

2001

253. Nematode-induced predisposition to secondary pathogens is primarily driven by:
(A) Physiological stress, root wounding, and leakage of exudates
(B) Nematode consumption of beneficial soil bacteria
(C) The synthesis of plant growth hormones by the nematode
(D) The physical blockage of xylem vessels by nematode bodies

2001

254. In the Meloidogyne-Fusarium complex, resistance breakdown is most severe when:
(A) Nematodes are introduced several weeks after the fungus.
(B) The fungus is introduced several weeks before the nematodes.
(C) Nematode infection precedes or coincides with fungal infection.
(D) The plant is grown in sterilized soil.

2025

255. Pratylenchus penetrans acts synergistically with Verticillium dahliae because its migratory feeding behavior:
(A) Creates extensive necrotic lesions that serve as entry courts
(B) Induces the formation of highly specialized giant cells
(C) Directly transports the fungus inside its gut
(D) Synthesizes viral particles

2012

256. Arthrobotrys oligospora transitions to a predatory lifestyle by forming adhesive networks primarily when:
(A) Nitrogen is abundant
(B) Carbon is scarce and nematode presence is detected
(C) Soil moisture is excessively high
(D) Plant roots release nematicides

2025

257. Which characteristic is definitive of Purpureocillium lilacinum?
(A) It forms constricting rings.
(B) It is a potent parasite of nematode eggs and sedentary females.
(C) It infects motile nematodes using zoospores.
(D) It belongs to the order Triplonchida.

2007

258. Consider the following statements regarding endoparasitic fungi:
I. Catenaria anguillulae uses zoospores to infect nematodes.
II. Hirsutella rhossiliensis uses adhesive conidia.
III. They develop their vegetative mycelium mostly inside the nematode body.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2013

259. What role do Meloidogyne species play in the disease complex with Ralstonia solanacearum?
(A) They provide entry wounds and alter host physiology, exacerbating bacterial wilt.
(B) They decrease the plant's susceptibility to the bacteria.
(C) They actively hunt and consume the bacteria.
(D) They serve as long-term survival structures for the bacteria in soil.

2025

260. Match the disease complex in List I with its interacting organisms in List II:
List I: (Disease Complex)
P. Tundu disease
Q. Potato early dying
R. Bacterial wilt complex
S. Fusarium wilt complex
List II: (Organisms)
1. Meloidogyne + Ralstonia
2. Anguina + Rathayibacter
3. Pratylenchus + Verticillium
4. Meloidogyne + Fusarium
(A) P-II, Q-III, R-I, S-IV
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-I, R-IV, S-II
(D) P-IV, Q-III, R-II, S-I

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ANSWERS

1. (B) Commensalism
Commensalism describes an ecological relationship where one species benefits from the activities of another without affecting it. In soil environments, nematode feeding often creates entry wounds in plant roots that secondary pathogens utilize for colonization. While the pathogen gains a significant advantage in infecting the host, the nematode population typically experiences no direct metabolic benefit or harm from this interaction.

2. (D) Nitrogen mineralization
Bacterivorous nematodes play a vital role in the soil nutrient cycle by consuming bacteria. Because these microorganisms contain more nitrogen than the nematodes require for their own growth, the excess is excreted back into the soil as ammonium. This process of nutrient mineralization converts organic nitrogen into inorganic forms, making it readily available for uptake by plants and other soil organisms.

3. (A) Physiological modification of host root exudates
Nematodes break plant genetic resistance by inducing profound physiological changes within the root tissues. The development of specialized feeding sites, such as giant cells or syncytia, alters the metabolic pathways and chemical composition of root exudates. These modifications can weaken the plant's constitutive defense barriers or provide a nutrient-rich environment that facilitates the establishment of secondary fungal pathogens.

4. (C) The interaction is strictly antagonistic
The relationship between root-knot nematodes and Fusarium wilt is synergistic, meaning the combined damage exceeds their individual impacts. Nematodes facilitate fungal infection by providing mechanical entry points and creating nutrient-rich giant cells that the fungus exploits. This complex interaction typically requires the nematode to infect the plant before the fungus to effectively break down the host's natural genetic resistance.

5. (A) Radopholus similis
Radopholus similis, the burrowing nematode, is the primary inciting agent of the devastating toppling disease in bananas. By tunneling through the root cortex and corm, it causes extensive necrosis and structural weakening. These lesions are frequently colonized by opportunistic soil fungi, leading to severe root rot. The combined destruction of the root system eventually causes the banana plant to fall over.

6. (D) Endospores
Arthrobotrys species are specialized predatory fungi that utilize various physical structures to capture nematodes in the soil. Common trapping mechanisms include adhesive three-dimensional networks, constricting rings, and adhesive knobs. However, endospores are not produced by this genus for prey capture; they are resistant survival structures typically associated with certain bacteria or other specific groups of parasitic fungi.

7. (B) Eggs and sedentary females
Purpureocillium lilacinum is a highly effective biocontrol fungus primarily utilized for its ability to parasitize the sedentary stages of plant-parasitic nematodes. It specifically targets nematode egg masses and the bodies of sedentary females. The fungus produces specialized enzymes, including chitinases and proteases, which degrade the protective layers of the eggs, allowing the mycelium to penetrate and consume the developing embryos.

8. (C) Hirsutella rhossiliensis - Adhesive spores
Hirsutella rhossiliensis is a specialized endoparasitic fungus that infects motile nematodes using adhesive conidia. These spores attach to the nematode's cuticle as it moves through the soil. Following attachment, the fungus produces a germ tube that penetrates the host body, eventually filling the entire pseudocoelom with vegetative mycelia. This process results in the death of the nematode and subsequent spore production.

NODIA

(B) Paralongidorus
(C) Xiphinema
(D) Trichodorus

2001

293. The loss of infectivity in virus-vectoring nematodes during moulting confirms that:
(A) The viruses are retained on the cuticular linings of the feeding apparatus, which are shed.
(B) The viruses are internally persistent and replicative.
(C) Moulting hormones actively degrade viral RNA.
(D) Nematodes only acquire viruses during their adult stage.

2023

294. Mechanical vectoring by nematodes often exacerbates disease caused by opportunistic rotting microorganisms because:
(A) The physical tissue damage and wounding provide entry points that the microbes could not create themselves.
(B) The nematodes secrete immunosuppressants into the plant sap.
(C) The nematodes provide essential nutrients that trigger microbial sporulation.
(D) The microbes replicate inside the nematode's reproductive tract.

2022

295. Which of the following is an example of an obligate mutualistic symbiosis involving nematodes?
(A) Steinernema and Xenorhabdus
(B) Meloidogyne and Fusarium
(C) Pratylenchus and Verticillium
(D) Globodera and AMF

2009

296. The primary contribution of bacterivorous nematodes to the soil ecosystem is:
(A) Accelerating nutrient mineralization and cycling by grazing on bacteria
(B) Transmitting plant viruses
(C) Directly synthesizing plant hormones
(D) Parasitizing plant roots

2010

297. Nematode-induced predisposition is most critical in breaking down plant resistance to which type of pathogen?
(A) Secondary soil-borne vascular wilt fungi (e.g., Fusarium)
(B) Foliar rusts
(C) Airborne viruses
(D) Powdery mildews

2008

298. The interaction between Meloidogyne and Fusarium oxysporum is defined as a synergistic disease complex because:
(A) The combined damage is significantly greater than the sum of the damage caused by each pathogen alone.
(B) The nematode kills the fungus.
(C) They compete for the same feeding site, neutralizing each other.
(D) The fungus protects the nematode from predators.

2014

299. Pratylenchus penetrans is a key component in the early dying disease complex of potato, interacting synergistically with:
(A) Phytophthora infestans
(B) Verticillium dahliae
(C) Streptomyces scabies
(D) Rhizoctonia solani

2021

300. Which trapping mechanism is characterized by a three-celled loop that rapidly inflates to capture a nematode?
(A) Constricting ring
(B) Adhesive network
(C) Adhesive knob
(D) Non-constricting ring

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18. (D) Xiphinema index
Grapevine fanleaf virus is specifically transmitted by the dagger nematode, Xiphinema index. This nematode acquires the virus while feeding on infected grape roots and retains the particles on the cuticular lining of its odontophore and esophageal bulb. Xiphinema index is the most important vector for this virus globally, causing significant economic damage in vineyards by facilitating the spread of the disease.

19. (A) Trichodoridae
Tobraviruses, such as Tobacco rattle virus, are exclusively transmitted by nematodes within the family Trichodoridae. This family includes the genera Trichodorus and Paratrichodorus, commonly known as stubby-root nematodes. These nematodes possess a solid, curved feeding spear called an onchiostyle. They retain viral particles on the cuticular lining of their pharynx and onchiostyle, transmitting them to various host plants during feeding.

20. (A) P-II, Q-I, R-IV, S-III
Virus-vectoring nematodes have specific retention sites within their feeding apparatus. In Xiphinema, viruses adhere to the odontophore lining, while in Longidorus, they are retained on the odontostyle lining. Trichodorus vectors retain viruses on the pharynx lining, and Paratrichodorus species utilize the onchiostyle lining. These specific binding sites ensure that only certain viruses are transmitted by their respective nematode vector species.

21. (A) They are lost with the shed exuviae.
Plant viruses transmitted by nematodes are typically lost during the moulding process. This occurs because the viral particles are retained on the cuticular lining of the nematode's feeding apparatus, which is entirely replaced and shed as part of the exuviae. Since these viruses do not replicate inside the nematode or enter its internal tissues, the new life stage must re-acquire them.

22. (D) Providing entry wounds and damaged tissue for colonization.
Nematodes acting as mechanical vectors facilitate disease by creating physical entry points through their feeding and migratory activities. These wounds and the associated damaged tissues are exploited by opportunistic microorganisms, such as soft-rot bacteria and secondary fungi, which lack the mechanisms to penetrate intact plant surfaces. This relationship is purely mechanical, as the pathogens do not require the nematode for biological reproduction.

23. (B) Predisposition
Predisposition refers to the phenomenon where a plant's natural resistance to a pathogen is compromised by a prior environmental or biological stressor. In nematology, this occurs when nematode infection alters the host's physiology or physical integrity, making a normally resistant cultivar susceptible to secondary soil-borne pathogens. This breakdown of resistance is often observed in complexes involving root-knot nematodes and Fusarium wilt.

24. (C) Bacterivorous nematodes
Bacterivorous nematodes are significant contributors to nitrogen mineralization within the soil food web. By grazing on bacterial populations, they release the excess nitrogen contained in their prey as ammonium. This process of nutrient mineralization converts organic nitrogen into inorganic forms, making it readily available for uptake by plants and other soil organisms.

25. (D) A synergistic disease complex
The interaction between Meloidogyne and Fusarium oxysporum f. sp. vasinfectum on cotton is a classic synergistic disease complex. The combined impact of the nematode and the fungus on plant health is much more severe than the sum of their individual effects. The nematode predisposes the cotton plant to fungal invasion by providing entry wounds and inducing physiological changes that favor fungal colonization.

26. (A) It alters root physiology and delays host defense responses.
In the Pratylenchus and Verticillium disease complex, the nematode primarily influences pathogenesis by altering the host's physiological state. The migratory endoparasitic feeding of Pratylenchus causes extensive root wounding and necrosis, which facilitates fungal entry. Furthermore, the nematode's presence can delay or suppress the plant's natural defense responses, allowing the fungal pathogen to colonize the vascular system more rapidly and severely.

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the odontophore and the esophageal bulb. In Longidorus species, the particles specifically bind to the lining of the odontostyle. This attachment is mediated by specific molecular interactions, ensuring that only the correct virus-vector pairs result in successful transmission to host plants.

63. (A) Nematode feeding frequency and moulting
The retention time of plant viruses within nematode vectors is primarily limited by the nematode's life cycle events. Moulting is the most critical factor, as it results in the shedding of the cuticular lining of the feeding apparatus where viruses are retained. Additionally, feeding frequency on non-host plants can gradually deplete the population of bound viral particles, reducing the nematode's overall transmission efficiency over time.

64. (C) Create physical wounds that opportunistic microbes exploit.
Nematodes facilitate root rots by acting as mechanical vectors, which means they create physical pathways for infection. Their stylet penetration and migratory activities result in numerous wounds and macerated tissues. Opportunistic soil-borne bacteria and fungi, which often lack the ability to penetrate healthy, intact roots, utilize these entry points to colonize the host and cause decay. This mechanical damage is a primary driver of complex diseases.

65. (A) Amensalism
Amensalism is an ecological interaction where one organism is inhibited or destroyed while the other remains unaffected. In the rhizosphere, this can occur when one soil microbe produces metabolic byproducts or toxins that are detrimental to a nematode species. The organism producing the substance gains no direct benefit from the suppression of the nematode, making the relationship asymmetrical in its impact on the two populations involved.

66. (D) By regulating fungal biomass and participating in nutrient cycling
Fungivorous nematodes play a crucial role in the soil food web by grazing on fungi. This feeding activity helps regulate fungal biomass and prevents any single species from becoming overly dominant. Furthermore, as they digest fungal tissue, they release excess nitrogen and other nutrients back into the soil environment. This process facilitates nutrient cycling and contributes to the overall stability and productivity of the soil ecosystem.

67. (B) Nematode-induced predisposition
Nematode-induced predisposition occurs when the presence of nematodes causes a normally resistant plant cultivar to become susceptible to a secondary fungal pathogen. This phenomenon is driven by the nematode's ability to alter host physiology and create mechanical entry points. These changes can suppress the plant's natural defense mechanisms, allowing pathogens like Fusarium to establish infection in cultivars that would otherwise effectively resist the disease.

68. (D) The nematode infects before the fungus.
In the Meloidogyne-Fusarium complex, the severity of wilt disease is highest when the nematode infects the plant before the fungal pathogen. This timing allows the nematode to establish feeding sites and induce the physiological changes necessary to predispose the host. By the time the fungus arrives, the root tissues are already modified and wounded, facilitating rapid fungal colonization of the vascular system and severe symptom expression.

69. (B) Premature plant senescence and severe wilting
The Pratylenchus and Verticillium disease complex, often called "early dying syndrome," is characterized by premature senescence and severe wilting of the host plant. The synergistic action of the migratory endoparasitic nematode and the vascular fungal pathogen results in rapid destruction of the root cortex and blockage of the xylem. This combined stress leads to significant yield loss and the early death of the plant in infested fields.

70. (A) P-II, Q-I, R-IV, S-III
Different nematophagous fungi utilize distinct trapping mechanisms. Arthrobotrys dactyloides forms constricting rings that inflate to capture prey. Monacrosporium ellipsosporum uses adhesive knobs. Dactylella lobata produces non-constricting rings, which act as passive snares. Arthrobotrys oligospora is famous for its three-dimensional adhesive networks. These specialized structures are adaptations that allow these fungi to switch from a saprophytic to a predatory lifestyle when nematode prey is available.

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36. (C) Competition leading to reduced population densities of one or both
When Meloidogyne incognita and Heterodera glycines co-infect a plant, they typically engage in interspecific competition for feeding sites and nutrients. This interaction often results in a reduction in the population density of one or both species compared to single-genus infections. The degree of suppression depends on factors like the timing of infection, host suitability, and the specific niches occupied within the root.

37. (A) Seinura
Seinura is a genus of predatory nematodes that utilizes a specialized hollow stylet to capture and kill its prey. Unlike mononchids that engulf prey, Seinura pierces the cuticle of other nematodes and injects a paralyzing toxin. Once the prey is immobilized, the predator sucks out the internal body contents. This rapid paralyzing mechanism allows Seinura to successfully attack nematodes that are much larger than itself.

38. (D) Triplonchida
The nematode family Trichodoridae belongs to the taxonomic Order Triplonchida. This group is characterized by the presence of an onchiostyle, which is a solid, curved feeding spear. Members of this family, including the genera Trichodorus and Paratrichodorus, are important because they are the exclusive vectors for Tobraviruses. They live as migratory ectoparasites, feeding on root tips and transmitting viruses during the process.

39. (A) Xiphinema diversicaudatum
Arabis mosaic virus is primarily transmitted by the dagger nematode, Xiphinema diversicaudatum. The nematode acquires the virus during feeding and retains the particles on the cuticular lining of its odontophore and esophageal bulb. This virus has a wide host range, and its spread in fields is closely linked to the distribution and movement of its specific nematode vector in the soil.

40. (A) II and III
Tobraviruses, including the well-known Tobacco rattle virus, are specifically transmitted by nematodes of the family Trichodoridae. Therefore, statements II and III are correct. Statement I is incorrect because they are not transmitted by Dorylaimida. Statement IV is incorrect because Tobraviruses are retained in the cuticular lining of the pharynx and onchiostyle, rather than the odontostyle, which is a structure found in Dorylaimid nematodes.

41. (A) The lining of the odontostyle
In Longidorus species, plant viruses are specifically retained on the cuticular lining of the odontostyle. This hollow feeding spear provides the primary binding site for viral particles during the acquisition process. Unlike Xiphinema, where viruses bind to the odontophore, Longidorus vectors maintain a specific relationship with Nepoviruses through this unique anatomical location, ensuring transmission to new hosts during subsequent feeding events.

42. (B) It causes an immediate loss of infectivity.
The moulting process causes an immediate loss of viral infectivity in nematode vectors. This occurs because the viral particles are retained on the cuticular lining of the feeding apparatus, which is entirely shed and replaced during the moult. Since these viruses do not replicate inside the nematode or enter its internal tissues, the new life stage must feed on an infected plant to re-acquire the virus.

43. (B) Mechanical facilitators providing entry through wounds
Secondary opportunistic rotting microorganisms primarily utilize plant-parasitic nematodes as mechanical facilitators. The feeding and migratory activities of nematodes create numerous physical wounds and areas of damaged tissue in the roots. These entry points allow bacteria and fungi, which may not possess independent penetration mechanisms, to colonize and rot the plant tissues, often leading to more severe damage than the nematodes alone.

44. (C) Competition
Competition occurs when two or more species utilize the same limited resources, such as feeding sites or nutrients, leading to mutual suppression of growth or reproduction. In nematology, this is often observed when different genera of plant-parasitic nematodes occupy the same root system. This interspecific interaction typically results in reduced population densities for one or both species as they vie for space in the host.

45. (D) Consuming pathogenic fungi and releasing sequestered nitrogen.
Fungivorous nematodes contribute to nutrient mineralization by grazing on soil fungi. Similar to

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These substances serve to inhibit the growth of competing opportunistic microorganisms and prevent the putrefaction of the insect cadaver. By maintaining a relatively "sterile" environment within the dead host, the bacteria ensure that the decaying tissues remain a suitable nutrient source exclusively for their own growth and for the reproduction of their nematode partners.

97. (C) Exosporium/parasporal fibers
The high host specificity of Pasteuria penetrans is primarily determined by the structural components of the endospore's outer layer, specifically the exosporium and its parasporal fibers. These structures contain specialized proteins or carbohydrates that act as ligands, recognizing and binding to specific receptors on the cuticle of certain nematode species. If this molecular matching does not occur, the endospore cannot attach, and the infection process is successfully avoided by the nematode.

98. (B) Upregulation of defense-related enzymes such as chitinases.
Arbuscular Mycorrhizal Fungi contribute to plant tolerance by inducing systemic resistance, which includes the upregulation of various defense-related enzymes. Increased production of chitinases and other pathogenesis-related proteins can help the plant better defend itself against invading nematodes. These biochemical changes, combined with improved nutrient uptake, allow the host to limit nematode development and withstand the physiological stress caused by the parasite more effectively than non-mycorrhizal plants.

99. (D) Cortex
Spatial competition between Arbuscular Mycorrhizal Fungi and sedentary endoparasitic nematodes is most intense within the root cortex. This tissue is the primary site where AMF establish arbuscules for nutrient exchange and where nematodes induce the formation of specialized feeding cells like giant cells or syncytia. Because both organisms require cortical space and host resources, their simultaneous presence often leads to mutual suppression and competition for limited space and carbon.

100. (A) P-IV, Q-III, R-I, S-II
Synergism occurs when the combined effect of two organisms exceeds the sum of their individual impacts. Antagonism describes one organism inhibiting another without a reciprocal benefit. Predisposition involves the breakdown of host resistance following a prior infection. Competition happens when both organisms suffer reduced fitness as they vie for shared limited resources. These concepts are fundamental to understanding the complex multi-trophic interactions that occur among nematodes and other soil-borne organisms.

101. (B) Meloidogyne induces galls in the vascular cylinder, while Pratylenchus creates lesions in the cortex.
During concomitant infection, Meloidogyne and Pratylenchus often occupy different niches within the root. Meloidogyne species typically migrate to the vascular cylinder to establish specialized giant cells and induce gall formation. In contrast, Pratylenchus species remain in the root cortex, where their migratory feeding leads to the development of necrotic lesions. This spatial partitioning allows both genera to coexist, although their activities can still lead to mutual suppression and overall root damage.

102. (A) A barrel-shaped stoma equipped with cuticular teeth
Predatory mononchid nematodes are primarily distinguished by their large, barrel-shaped buccal cavity, or stoma. This structure is heavily sclerotized and typically features one or more prominent cuticular teeth, which may be located on the dorsal or ventral walls. These anatomical features are adaptations for an active predatory lifestyle, allowing the nematodes to grasp, puncture, and consume other soil-dwelling organisms, including various types of plant-parasitic and free-living nematodes.

103. (A) Trichodoridae
The taxonomic Order Triplonchida includes the family Trichodoridae, which contains important virus-vectoring nematode genera like Trichodorus and Paratrichodorus. These nematodes are distinguished by their unique feeding spear, called an onchiostyle, which is solid and curved. They are the only known vectors for Tobraviruses, such as Tobacco rattle virus. They function as migratory ectoparasites, feeding on the external surfaces of root tips and transmitting viruses during the process.

NODIA

54. (C) Intestine
The symbiotic bacteria Xenorhabdus and Photorhabdus reside within a specialized region of the intestine in entomopathogenic nematodes. In Steinernema, Xenorhabdus is kept in a specialized bacterial vesicle, whereas in Heterorhabditis, Photorhabdus is distributed throughout the gut. These bacteria remain in a quiescent state until the nematode's infective juvenile stage penetrates an insect host, where they are released to initiate the infection.

55. (A) Depletion of body contents and release of endospores
The terminal stage of a Pasteuria penetrans infection occurs when the bacterial mycelia fully mature into endospores, completely filling the body of the host nematode. This process leads to the total depletion of the nematode's internal body contents and eventually its death. As the nematode carcass decomposes in the soil, millions of mature endospores are released, which can then attach to and infect new host juveniles.

56. (C) Direct synthesis of nematode-specific toxins by the fungus
Arbuscular Mycorrhizal Fungi confer tolerance through several mechanisms, but the direct synthesis of nematode-specific toxins is not typically one of them. Instead, they improve host health through enhanced phosphorus uptake, altered root morphology, and the activation of the plant's systemic defense responses. These changes help the plant better withstand the stress of nematode infection and compete for limited root space and photosynthetically derived carbon.

57. (A) Spatial and nutritional competition
Sedentary endoparasitic nematodes and Arbuscular Mycorrhizal Fungi both rely heavily on host-derived carbon and occupy cortical root tissues. This shared requirement frequently results in intense spatial and nutritional competition. When both are present, they compete for available space to establish their respective feeding sites, which can lead to reduced colonization by the fungus or suppressed reproduction and development of the nematode population.

58. (D) Niche overlap and population reduction for one or both species
Concomitant infection by two different plant-parasitic nematode species usually leads to niche overlap and interspecific competition. This interaction typically results in a reduction in the population density of one or both species as they vie for limited resources like feeding sites and nutrients. The outcome is often asymmetrical, where one species is more severely affected based on its competitive ability and the timing of root colonization.

59. (A) Mononchus
Mononchus is a predatory nematode that possesses a large, barrel-shaped stoma. Although many mononchids have teeth, the genus is primarily defined by this robust buccal cavity used to capture prey. They can engulf smaller nematodes whole or use their mouthparts to puncture the cuticle and suck out the internal contents of larger prey. These predators are important natural regulators of other nematode populations in diverse soil environments.

60. (B) Both A and R are true but R is not the correct explanation of A.
Both statements are true: members of the family Trichodoridae transmit Tobraviruses, and these viruses are retained on the cuticular lining of the nematode's pharynx and onchiostyle. However, the retention site itself does not explain why this specific group of nematodes vectors the virus; rather, the transmission depends on highly specific molecular recognition between the viral coat protein and the cuticular binding sites.

61. (B) Tobravirus
Pea early-browning virus belongs to the genus Tobravirus. This group of viruses is characterized by rod-shaped particles and a bipartite RNA genome. Like other Tobraviruses, such as Tobacco rattle virus, it is specifically transmitted by nematodes within the family Trichodoridae, including the genera Trichodorus and Paratrichodorus. The virus is retained on the cuticular lining of the nematode's feeding apparatus and transmitted during feeding.

62. (B) Odontostyle and odontophore
Nepoviruses typically attach to specific cuticular linings within the feeding apparatus of their vector nematodes. In Xiphinema species, the virus particles are retained on the lining of

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to minimize direct niche overlap. While both require specialized feeding sites in the vascular cylinder, they may colonize different parts of the root or establish themselves at different times, resulting in a distinct spatial distribution that allows both populations to persist.

80. (A) I and II
Statements I and II are correct. Mononchids are predatory nematodes with a heavily cuticularized stoma equipped with teeth, while Seinura species use a specialized stylet to inject paralyzing toxins into their prey. Statement III is incorrect because diplogasterids are not exclusively root-feeders; many are opportunistic predators or bacterivores found in decaying organic matter and soil, often feeding on other small organisms including nematodes.

81. (D) Longidoridae
The nematode family Longidoridae includes several genera, such as Xiphinema and Longidorus, which are known vectors for Nepoviruses. These nematodes are relatively large and possess a long, hollow odontostyle used for feeding deep within root tissues. They acquire viral particles from infected plants and retain them on the cuticular lining of their feeding apparatus, facilitating the spread of various plant diseases through their migratory feeding behavior.

82. (D) Arabis mosaic virus
Arabis mosaic virus is a recognized Nepovirus that is transmitted by the dagger nematode Xiphinema diversicaudatum. Like other Nepoviruses, it is characterized by isometric particles and a bipartite genome. The virus is acquired by the nematode during feeding and is retained at specific binding sites within the odontophore lining. This specific relationship ensures the efficient transmission of the virus between susceptible host plants in the field.

83. (A) Tobraviruses
Trichodorus and Paratrichodorus species, collectively known as stubby-root nematodes, are the exclusive vectors for Tobraviruses. This group includes important plant pathogens like Tobacco rattle virus and Pea early-browning virus. These nematodes utilize their solid, curved onchiostyle to feed on root tips, during which they acquire and transmit the virus. The viral particles are retained on the cuticular lining of the pharynx and onchiostyle between feeding events.

84. (B) Pharynx and onchiostyle
In Trichodorus species, plant viruses are specifically retained on the cuticular lining of the pharynx and the onchiostyle. This anatomical region provides the necessary binding sites for the viral particles. As the nematode feeds on an infected plant, the virus adheres to these surfaces. When the nematode subsequently feeds on a healthy host, the particles are released and inoculated into the plant tissue, completing the transmission cycle.

85. (D) Minimum feeding time required for a nematode to acquire a transmissible virus
The acquisition access period refers to the minimum amount of time a vector nematode must feed on an infected host plant to successfully acquire a transmissible amount of virus. This period varies depending on the specific virus-vector combination and environmental conditions. Once the virus is acquired and bound to the retention sites in the feeding apparatus, the nematode becomes viruliferous and capable of transmitting the virus to healthy plants.

86. (D) They do not replicate within the nematode vector.
Nematode-transmitted viruses are not classified as persistent-propagative because they do not replicate within their nematode vectors. Instead, they are typically described as non-persistent or semi-persistent. The viral particles simply adhere to the cuticular lining of the feeding apparatus and are lost during the moulting process. This lack of internal replication and circulation through the hemocoel distinguishes them from certain viruses transmitted by insect vectors.

87. (B) Mechanical vectoring
When nematodes facilitate secondary fungal decay of storage roots by creating entry points, the interaction is described as mechanical vectoring. The nematodes do not have a specialized biological relationship with the fungi; rather, their physical activities provide the necessary pathways for opportunistic microbes to bypass the plant's protective outer layers. This wounding and subsequent colonization lead to rapid decay and significant post-harvest losses in crops like sweet potato and yam.

NODIA

71. (C) Egg masses on the root surface
The egg masses of Meloidogyne species, which are typically found on the root surface, are highly susceptible to parasitism by Pochonia chlamydosporia. This fungus colonizes the gelatinous matrix of the egg mass and enzymatically penetrates the eggshells to consume the developing juveniles. By targeting this stage, the fungus effectively prevents the next generation of nematodes from hatching and infecting new root tissues.

72. (B) Adhesive conidia
Hirsutella rhossiliensis is an endoparasitic fungus that infects host nematodes using specialized adhesive conidia. These spores are produced on phialides and remain attached to the fungal mycelium until they come into contact with a passing nematode. Once a spore adheres to the cuticle, it germinates and penetrates the body wall. The fungus then grows internally, eventually consuming the host and producing new spores on the carcass.

73. (B) Tomato
The interaction between Meloidogyne species and Ralstonia solanacearum is a major problem in tomato cultivation. Root-knot nematodes cause extensive galling and physiological changes that significantly increase the plant's susceptibility to bacterial wilt. In many tomato-growing regions, this synergistic complex can lead to the total loss of the crop, as the nematodes facilitate the rapid spread and establishment of the bacteria within the plant's vascular system.

74. (B) Be transported from the soil to the developing floral primordia.
Rathayibacter tritici uses the nematode Anguina tritici as a transport vector to reach the developing floral primordia of wheat. The non-motile bacteria adhere to the cuticle of the nematode's infective juveniles. As the nematodes migrate from the soil through the plant tissues to reach the apex, they carry the bacteria with them. Without this nematode-mediated transport, the bacteria cannot infect the wheat ear to cause Tundu disease.

75. (D) Penetration into the insect hemocoel
The release of symbiotic Xenorhabdus bacteria from the infective juvenile of Steinernema is triggered by the nematode's penetration into the insect hemocoel. Upon entering the nutrient-rich hemolymph, the nematode undergoes physiological changes that cause it to void the bacteria from its specialized intestinal vesicle. Once released, the bacteria multiply rapidly and produce the toxins and enzymes necessary to kill the insect host and facilitate nematode reproduction.

76. (D) Parasporal fibers on the endospore
The attachment of Pasteuria penetrans endospores to the nematode cuticle is facilitated by specialized structures known as parasporal fibers. These fibers are part of the outer exosporium and contain specific ligands that bind to complementary receptors on the surface of susceptible nematode species. This molecular recognition ensures high host specificity, as the endospores will only adhere to and subsequently infect specific types of nematodes encountered in the soil.

77. (B) Decreased attraction or repulsion of nematode juveniles
Arbuscular Mycorrhizal Fungi colonization can alter the chemical profile of root exudates, which often leads to decreased attraction or even repulsion of nematode infective juveniles. By changing the signals released into the rhizosphere, AMF can reduce the number of nematodes that successfully locate and penetrate the host roots. this biochemical modification is one of the many indirect ways that mycorrhizal fungi help protect plants from nematode damage.

78. (A) Photosynthetically derived carbon
When Arbuscular Mycorrhizal Fungi and sedentary endoparasitic nematodes occupy the same root system, photosynthetically derived carbon becomes the primary limiting resource. Both organisms are "carbon sinks" that rely entirely on the host plant for their energy requirements. The intense competition for these sugars can lead to reduced fungal colonization or suppressed nematode development, as the host plant struggles to support the metabolic demands of both symbionts.

79. (D) Spatial separation, with Root-knot nematodes occupying different root zones than Cyst nematodes
In cases of concomitant infection by root-knot and cyst nematodes, competition often leads to spatial separation within the root system. Each genus tends to occupy different zones or tissues

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bacterivores, these nematodes consume microbial biomass that contains higher concentrations of nitrogen than they require. As they digest the fungi, they release excess nitrogen back into the soil as ammonium. This process not only regulates fungal populations but also converts organic nutrients into forms that can be easily absorbed by plant roots.

46. (D) Nematode-induced physiological changes and wounding
Genetic resistance to secondary soil pathogens is most commonly compromised by the physiological changes and physical wounding induced by nematode infection. Nematodes create entry ports through their stylet activity and induce specialized feeding structures that act as nutrient sinks. These alterations can suppress the host's natural defense pathways, allowing pathogens like Fusarium or Verticillium to overcome the genetic resistance that would otherwise protect the plant.

47. (B) Synergistic
The interaction between Meloidogyne species and Fusarium oxysporum is characterized as synergistic. In this relationship, the presence of both organisms leads to disease severity that is significantly greater than the sum of their individual effects. The nematode predisposes the plant to fungal infection through mechanical wounding and metabolic modifications, creating a favorable environment for the fungus to colonize the vascular system.

48. (C) Verticillium dahliae
Pratylenchus penetrans is notoriously involved in a synergistic disease complex with Verticillium dahliae, a condition often referred to as "potato early dying." The migratory endoparasitic feeding of the nematode causes extensive root wounding and necrosis, which facilitates the entry of the fungus into the xylem. Together, these pathogens cause premature senescence and significant yield reductions in potato crops that are much more severe than individual infections.

49. (D) Arthrobotrys
The genus Arthrobotrys is famous for its ability to produce adhesive three-dimensional networks to capture soil nematodes. These networks are formed from specialized hyphae coated with a sticky substance that ensnares nematodes upon contact. Once a nematode is trapped, the fungus produces infection pegs that penetrate the cuticle, allowing the mycelia to grow internally and digest the prey's tissues as a nutrient source.

50. (A) I, II, IV and V
Statement I, II, IV, and V are correct. Purpureocillium lilacinum is an egg parasite. Hirsutella rhossiliensis is an endoparasite. Monacrosporium species often utilize adhesive structures. Catenaria anguillulae infects hosts using motile zoospores. Statement III is incorrect because Pochonia chlamydosporia is an egg and female parasite that does not form constricting rings; such rings are characteristic of predatory fungi like Arthrobotrys dactyloides.

51. (D) Develops its vegetative structures entirely within the host body.
Catenaria anguillulae is classified as an endoparasitic fungus because it completes almost its entire vegetative life cycle within the body of the host nematode. After the infectious zoospores encyst and penetrate the host, the resulting mycelia grow internally, consuming the pseudocoelomic contents. The fungus only produces external structures, such as exit tubes, when it is ready to release new zoospores into the environment.

52. (B) Bacterial wilt
The synergistic interaction between Meloidogyne species and Ralstonia solanacearum leads to a highly severe incidence of bacterial wilt. The nematodes provide physical entry points through their feeding wounds and induce physiological changes in the host roots that facilitate the rapid colonization of the vascular system by the bacteria. This complex often results in the breakdown of wilt resistance in crops like tomatoes and peppers.

53. (A) Cuticle
In the Tundu disease complex, the infective second-stage juveniles of Anguina tritici carry Rathayibacter tritici bacteria adhered to their external cuticle. This mechanical carriage is highly specific and allows the non-motile bacteria to be transported from the soil into the developing floral primordia of the wheat plant. Once the nematodes reach the apex, the bacteria multiply rapidly, leading to the characteristic yellow slime symptoms.

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88. (D) Fungivores
Fungivorous nematodes are a group of soil organisms that feed exclusively on fungi rather than plants. They use a small stylet to puncture fungal hyphae and suck out the internal contents. These nematodes are important components of the soil food web, as they help regulate fungal populations and participate in nutrient cycling. By consuming fungi, they release nitrogen and other elements back into the soil, benefiting the overall ecosystem.

89. (D) Disease synergism
The breakdown of plant genetic resistance to Fusarium wilt by Meloidogyne incognita is a classic example of disease synergism. In this interaction, the nematode alters the host's physiological state and provides mechanical entry wounds, which allows the fungus to overcome the plant's natural resistance mechanisms. The resulting disease severity is much greater than would be expected from the independent action of either pathogen, leading to devastating crop damage.

90. (C) III
Statement III is incorrect because the interaction between Pratylenchus and Verticillium typically increases, rather than decreases, the overall severity of wilt. This synergistic complex is a major factor in "potato early dying" syndrome. Statements I, II, and IV are correct: the complex is common in mint and potato, the nematode's migratory endoparasitic feeding provides entry ports for the fungus, and Pratylenchus species are indeed migratory endoparasites.

91. (B) Detection of nematode-specific cues (ascarosides) and low nutrients
Arthrobotrys oligospora transitions from a saprophytic to a predatory lifestyle in response to environmental cues, particularly the detection of nematode-produced pheromones called ascarosides. This transition is also stimulated by nutrient-limiting conditions in the soil. Under these stresses, the fungus begins to produce specialized adhesive traps to capture nematodes, providing a rich source of nitrogen and other essential nutrients that are otherwise unavailable in the environment.

92. (A) Purpureocillium lilacinum
Purpureocillium lilacinum is the most commercially utilized biocontrol fungus for managing root-knot nematodes due to its exceptional ability to parasitize eggs. It is a common soil fungus that can be mass-produced and applied to fields. The fungus colonizes the nematode egg masses and uses a combination of mechanical pressure and enzymatic activity to penetrate the eggshells, ultimately killing the developing embryos and reducing the overall nematode population.

93. (A) Adhesive conidia or zoospores
Endoparasitic fungi that target motile nematode stages typically initiate infection using specialized structures like adhesive conidia or motile zoospores. Adhesive conidia, such as those of Hirsutella, stick to the nematode's cuticle upon contact. Zoospores, like those of Catenaria, are attracted to nematode secretions and encyst on the host's body. Both mechanisms allow the fungus to attach to and eventually penetrate the motile host to begin its internal life cycle.

94. (B) A shortened incubation period for bacterial wilt symptom expression.
Combined infection by Meloidogyne and Ralstonia solanacearum often results in a significantly shortened incubation period for bacterial wilt. The wounding and physiological changes induced by the nematode facilitate the rapid entry and systemic spread of the bacteria within the plant's vascular system. This acceleration of disease development leads to earlier symptom expression and more severe wilting, often causing the host plant to succumb to the infection much faster.

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95. (B) The infective second-stage juvenile (J2) cuticle
In the yellow ear rot disease complex of wheat, the non-motile Rathayibacter tritici bacteria are carried on the external cuticle of the infective second-stage juveniles of Anguina tritici. This mechanical carriage allows the bacteria to be transported as the nematodes migrate from the soil into the developing floral primordia of the plant. The bacteria stay adhered to the nematode until they reach the target tissue, where they multiply and cause disease.

96. (B) Prevent putrefaction by inhibiting competing opportunistic microbes.
Xenorhabdus bacteria produce a variety of secondary metabolites, including antibiotics and antifungal compounds, inside the insect host.

27. (B) Constricting rings
Constricting rings are active trapping structures produced by certain nematophagous fungi like Arthrobotrys dactyloides. These traps consist of three specialized cells that respond to physical contact by a nematode. Upon stimulation, the cells undergo rapid inward expansion, triggered by a sudden increase in turgor pressure. This mechanism effectively cinches the ring around the nematode body, ensnaring it for subsequent fungal penetration.

28. (D) Parasitizing nematode eggs and sedentary females.
Pochonia chlamydosporia is a specialized fungal parasite that targets the reproductive stages of plant-parasitic nematodes. It primarily colonizes the rhizosphere and infects nematode egg masses on the root surface. The fungus enzymatically penetrates the eggshells and the bodies of sedentary females, consuming the internal contents. This action significantly reduces the population of cyst and root-knot nematodes by preventing successful reproduction and hatching.

29. (A) Catenaria anguillulae
Catenaria anguillulae is an endoparasitic fungus that utilizes motile zoospores to find and infect its nematode hosts. These flagellated spores are attracted to the nematode's natural orifices, such as the mouth or excretory pore, where they encyst and germinate. Once inside, the fungus develops its vegetative mycelia within the host's body, eventually consuming all internal tissues and producing new zoospores for dispersal.

30. (B) I and III
Statement I is incorrect because nematode infection typically precedes bacterial colonization in these complexes. Statement III is incorrect because giant cells do not restrict bacterial multiplication; instead, the metabolic changes and wounding induced by the nematode often favor the rapid establishment and spread of Ralstonia solanacearum. Statement II is correct, as nematode-induced wounds are well-known to facilitate the entry of bacteria.

31. (C) The nematode acts as an essential vector to transport the bacterium.
The relationship between Rathayibacter tritici and Anguina tritici is characterized by the nematode serving as an essential transport vector. The non-motile bacteria adhere to the cuticle of the nematode's infective second-stage juveniles. As the nematodes migrate from the soil to the developing wheat apex and floral primordia, they carry the bacteria along, enabling the development of yellow ear rot symptoms.

32. (B) Heterorhabditis
Photorhabdus bacteria are mutualistically associated with entomopathogenic nematodes of the genus Heterorhabditis. These bacteria are carried in the intestine of the nematode's infective juvenile stage. Once inside an insect host, the bacteria are released, producing toxins and antimicrobial compounds that kill the insect and protect the cadaver from competing microbes. This symbiosis is essential for the reproduction of both the nematode and bacterium.

33. (A) Forms a germ tube that penetrates the host cuticle directly.
Pasteuria penetrans is an obligate bacterial parasite with a unique infection mechanism. After an endospore attaches to the cuticle of a moving nematode juvenile, it germinates and forms a specialized germ tube. This structure penetrates directly through the nematode's thick cuticle into the pseudocoelom. Once inside, the bacterium develops as a mycelial colony, eventually consuming the host's reproductive system and forming new endospores.

34. (C) Phosphorus
Arbuscular Mycorrhizal Fungi primarily enhance host tolerance to nematode infection by improving the uptake of phosphorus. Mycorrhizal roots have a significantly larger surface area for nutrient absorption, allowing the plant to maintain high levels of vigor despite the damage to its root system. This improved phosphorus nutrition helps the plant compensate for biomass losses and support the high metabolic costs of nematode parasitism.

35. (D) Cortical root tissues
Interspecific competition between sedentary endoparasitic nematodes and Arbuscular Mycorrhizal Fungi occurs primarily within the cortical tissues of the root. Both organisms require these cells to establish their specialized structures; AMF form arbuscules for nutrient exchange, while nematodes induce giant cells or syncytia for feeding. The limited availability of cortical space and host carbon resources often leads to mutual suppression in these tissues.

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104. (A) Tomato ringspot virus (ToRSV)
Tomato ringspot virus is a well-known Nepovirus that is associated with and transmitted by nematodes of the Xiphinema americanum group. These nematodes acquire the virus while feeding on infected roots and retain it on the cuticular lining of their odontophore and esophageal bulb. Xiphinema americanum is a widespread vector in North America, facilitating the spread of this virus in a variety of important fruit and ornamental crops.

105. (D) Rod-shaped, bipartite genome particles
Tobraviruses are characterized by having rigid, rod-shaped particles of two different lengths. This morphology reflects their bipartite RNA genome, where the larger particle contains RNA-1 and the smaller particle contains RNA-2. This structural organization is unique among nematode-transmitted viruses and is a defining feature of the genus. They are transmitted exclusively by members of the family Trichodoridae, which retain the viral particles on the lining of their pharynx and onchiostyle.

106. (C) Cuticle (carbohydrate-based)
In the nematode vector Xiphinema index, the viral retention site is part of the internal feeding apparatus, which is lined with a specialized cuticular layer. This carbohydrate-based cuticle provides the surface to which the viral particles, such as Grapevine fanleaf virus, specifically adhere. The molecular interactions between the viral coat protein and this cuticular lining are highly specific, ensuring that only the correct virus is successfully retained and subsequently transmitted to a new host plant.

107. (A) Viruses are retained on shed cuticular linings.
The loss of viral infectivity during the nematode moulting process is definitive proof that the viruses are retained on the cuticular linings of the feeding apparatus. Since the entire lining of the stoma, esophagus, and stylet is shed and replaced during each moult, any bound viral particles are removed with the old cuticle. This indicates that the viruses do not enter the nematode's internal tissues or replicate inside the vector's body.

108. (A) Transmit pathogens purely through physical contamination or wounding
Mechanical vectors differ from biological vectors because they transmit pathogens purely through physical means, such as contamination of their mouthparts or by creating entry wounds. The pathogen does not undergo any part of its life cycle or replication within the mechanical vector. In nematology, this is common when nematodes create wounds that opportunistic soil bacteria or fungi exploit, facilitating disease without a specific, evolved biological relationship between the two organisms.

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109. (D) Indirect commensalism or mutualism via nutrient cycling
The relationship between plant roots and beneficial non-parasitic nematodes, such as bacterivores and fungivores, is generally described as indirect mutualism. These nematodes do not feed on the plant itself; instead, they consume soil microorganisms. By grazing on bacteria and fungi, they accelerate the process of nutrient mineralization, releasing essential elements like nitrogen back into the soil. This increased nutrient availability directly benefits plant growth, creating a mutually beneficial soil environment.

110. (C) A is true but R is false.
Assertion A is true: interspecific competition among plant-parasitic nematodes is common as they often vie for limited root resources. However, Reason R is false because different nematode species rarely have identical feeding site requirements. For example, root-knot nematodes induce giant cells, while cyst nematodes form syncytia. Competition arises from the general demand for space and host-derived nutrients within the same root system, rather than perfectly identical biological needs.

111. (B) Leakage of root exudates through mechanical and enzymatic wounding
Nematodes predispose plants to secondary pathogens primarily by causing mechanical and enzymatic wounding during their feeding and migratory activities. This damage leads to the leakage of various root exudates, such as sugars and amino acids, into the rhizosphere. These nutrients attract and stimulate the growth of opportunistic soil-borne fungi and bacteria. Additionally, the physical wounds provide direct entry points for pathogens that would otherwise be unable to penetrate healthy root tissues.

112. (B) Cotton
The presence of Meloidogyne species often breaks down the natural genetic resistance to Fusarium

160. (A) Endospore attachment, germ tube penetration, vegetative mycelial growth, sporulation
The lifecycle of Pasteuria penetrans follows a specific sequence: it begins with the attachment of an endospore to the cuticle of a moving nematode juvenile. After attachment, the spore germinates and forms a germ tube that penetrates the host's body. Once inside the pseudocoelom, the bacterium undergoes vegetative mycelial growth, eventually consuming the host's internal tissues. Finally, the mycelia fragment and mature into new endospores, which are released back into the soil.

161. (B) Adhesive three-dimensional networks
Arthrobotrys oligospora is primarily known for capturing nematodes using specialized adhesive three-dimensional networks. These traps are formed from hyphal loops that are coated with a sticky substance. When a nematode comes into contact with the network, it becomes physically ensnared. The fungus then produces infection hyphae that penetrate the nematode's cuticle to grow internally and digest its tissues. This predatory behavior allows the fungus to obtain essential nutrients, particularly in nitrogen-limited environments.

162. (C) Pochonia chlamydosporia
Pochonia chlamydosporia is a highly effective biocontrol agent that primarily parasitizes the sedentary females and eggs of cyst and root-knot nematodes. It colonizes the rhizosphere and the gelatinous matrix of the egg masses. The fungus uses a combination of mechanical pressure and specialized enzymes to penetrate the eggshells and consume the developing embryos. By targeting the reproductive stage, it significantly reduces the population of plant-parasitic nematodes and limits their spread in agricultural soils.

163. (C) Zoosphere
The infectious stage of the endoparasitic fungus Catenaria anguillulae is the motile zoospore. These flagellated spores move through the film of water in the soil and are attracted to the secretions from nematode body orifices, such as the mouth or excretory pore. Once they find a host, the zoospores encyst on the cuticle and germinate, sending infection hyphae into the nematode's body to begin the parasitic phase of their life cycle.

164. (B) Accelerated and more severe bacterial wilt symptoms
Co-infection of tomato roots by Meloidogyne and Ralstonia solanacearum typically results in accelerated and more severe bacterial wilt symptoms. The nematode's feeding creates entry wounds and induces physiological changes that facilitate the rapid colonization of the vascular system by the bacteria. This synergistic relationship leads to a shorter incubation period and a much faster progression of wilting compared to single infections, often causing total crop failure in heavily infested areas.

165. (C) Adhered securely to their external cuticle
In the Tundu disease complex of wheat, the infective second-stage juveniles (J2) of Anguina tritici transmit the bacterium Rathayibacter tritici by carrying the bacterial cells adhered securely to their external cuticle. This mechanical carriage is highly specific and essential for the bacterium's survival and dispersal. As the nematodes migrate from the soil into the developing floral primordia of the wheat plant, they transport the non-motile bacteria, enabling the development of yellow slime symptoms.

166. (C) Tissues digested by Xenorhabdus bacteria
The primary nutritional source for Steinernema nematodes developing inside an insect host is the tissue that has been digested by their symbiotic Xenorhabdus bacteria. Once the bacteria are released into the insect's hemocoel, they produce a variety of enzymes that break down the host's complex proteins and fats into a nutrient-rich soup. The nematodes then graze on this pre-digested material and the multiplying bacterial cells, which provide all the essential nutrients for their growth.

167. (B) Penetration of the cuticle via a germ tube
Following the attachment of Pasteuria penetrans endospores to the nematode cuticle, the next step is the germination of the spore and the penetration of the cuticle via a germ tube. The germ tube grows directly through the thick layers of the nematode's integument and enters the pseudocoelom. Once inside this nutrient-rich internal cavity, the bacterium begins its vegetative growth phase, eventually forming a large mycelial colony that consumes the host's reproductive organs.

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primarily infects the juvenile and adult stages of the nematode by attaching to their cuticle, rather than targeting the eggs. The bacterium eventually consumes the internal contents of the adult female, preventing reproduction.

121. (B) AMF establishes in the roots prior to nematode infection.
Mycorrhiza-mediated tolerance is most effective when the Arbuscular Mycorrhizal Fungi are allowed to establish in the root system before nematode infection occurs. Early colonization gives the fungus time to improve the plant's nutrient status and induce systemic defense responses. This "head start" allows the host to better withstand the subsequent stress of nematode feeding and competition for space within the root cortex, resulting in improved plant growth and yield.

122. (C) Antagonism
The interaction between Rhizobium and Meloidogyne is classified as antagonism because the nematode negatively impacts the beneficial nitrogen-fixing symbiosis. By infecting the roots and inducing gall formation, Meloidogyne species interfere with the development and function of nitrogen-fixing nodules. This competition for root space and host resources leads to reduced nodulation and impaired nitrogen fixation, which ultimately harms the growth and productivity of the legume host.

123. (A) Niche partitioning
Niche partitioning occurs when two or more species co-exist by utilizing different resources or occupying distinct areas within the same environment. In the root system, this is observed when different nematode species inhabit separate tissues, such as one genus colonizing the cortex while another establishes itself in the vascular cylinder. This spatial separation reduces direct competition for feeding sites, allowing multiple nematode species to persist on the same host plant.

124. (A) Use a stylet to pierce prey and inject paralyzing secretions
Seinura species are predatory nematodes that utilize a hollow stylet to attack their prey. Unlike mononchids, which have a large buccal cavity for engulfing organisms, Seinura pierces the cuticle of its target and injects potent, paralyzing secretions. This immobilization allows the predator to feed on the internal contents of the prey at its leisure. This specialized mechanism is highly effective for hunting other soil-dwelling nematodes, including those larger than the predator itself.

125. (A) Dorylaimida possess an odontostyle; Triplonchida possess an onchiostyle.
The Orders Dorylaimida and Triplonchida are distinguished by the morphology of their feeding spears. Dorylaimid nematodes, such as Xiphinema, possess a hollow, axial spear called an odontostyle. In contrast, nematodes in the Order Triplonchida, like Trichodorus, have a solid, curved spear known as an onchiostyle. These structural differences are accompanied by different viral transmission specificities, with Dorylaimids vectoring Nepoviruses and Triplonchids vectoring Tobraviruses.

126. (A) Xiphinema
Strawberry latent ringspot virus is a plant pathogen that is associated with and transmitted by nematodes of the genus Xiphinema. The nematode acquires the virus while feeding on the roots of infected plants and retains it on the cuticular lining of its odontophore and esophageal bulb. As a migratory ectoparasite, Xiphinema moves through the soil, facilitating the spread of this virus to various horticultural crops, including strawberries and raspberries.

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127. (C) Trichodorus
Tobacco rattle virus is exclusively transmitted by nematodes in the family Trichodoridae, primarily the genus Trichodorus. These stubby-root nematodes acquire the virus as they feed on the external cells of root tips using their solid onchiostyle. The viral particles are retained on the cuticular lining of the pharynx and onchiostyle. This virus-vector relationship is highly specific, and the spread of TRV in fields depends on the presence of these particular nematodes.

128. (A) The lining of the odontostyle
In Longidorus species, the specific site for viral retention is the cuticular lining of the odontostyle. Unlike Xiphinema, where viruses bind to the odontophore and esophageal bulb, Longidorus vectors have adapted this more anterior structure for virus attachment. The molecular affinity between the viral coat protein and the odontostyle lining ensures that only specific Nepoviruses are retained and

wilt in cotton. This synergistic interaction was one of the earliest described disease complexes. The nematodes create entry wounds and induce physiological changes in the cotton roots that facilitate the colonization of the vascular system by Fusarium oxysporum f. sp. vasinfectum. This often results in severe wilting and crop loss, even in cotton cultivars designed to be resistant.

113. (B) Modifying the host physiology and creating entry courts
Pratylenchus species contribute to Verticillium wilt complexes primarily through their migratory endoparasitic behavior. As they move through the root cortex, they cause extensive mechanical wounding and tissue necrosis, creating ideal entry courts for the fungal pathogen. Furthermore, their feeding modifies the host's physiological state, which can delay or suppress the plant's defense responses, allowing Verticillium to rapidly colonize the xylem and cause severe "early dying" symptoms.

114. (A) Dactylella
Certain species within the genus Dactylella are known to capture soil nematodes using non-constricting rings. These structures are passive traps consisting of a three-celled ring that does not inflate. Instead, a nematode becomes wedged inside the ring as it attempts to crawl through. Once the prey is ensnared, the fungus produces infection hyphae that penetrate the nematode's cuticle to consume its internal tissues, providing the fungus with essential nutrients.

115. (D) It colonizes the rhizosphere and penetrates nematode eggs enzymatically.
Pochonia chlamydosporia is a specialized biocontrol agent that primarily targets the eggs of cyst and root-knot nematodes. It colonizes the root surface and the gelatinous matrix surrounding the egg masses. The fungus then utilizes a combination of mechanical pressure and specialized enzymes, such as proteases and chitinases, to penetrate the eggshell. Once inside, it consumes the developing juvenile, effectively preventing the completion of the nematode's life cycle.

116. (A) Catenaria anguillulae
Catenaria anguillulae is an endoparasitic fungus that produces motile, flagellated zoospores to locate and infect its nematode hosts. These zoospores move through soil water and are attracted to the nematode's natural orifices, where they encyst and germinate. The fungus then grows internally, eventually filling the entire body of the nematode with its vegetative structures. This unique motile stage allows the fungus to actively seek out and infect its prey in wet soil.

117. (C) Nematode infection significantly accelerates bacterial wilt severity.
The disease complex between Meloidogyne and Ralstonia solanacearum is particularly devastating because the nematode infection significantly accelerates the severity and onset of bacterial wilt. By creating mechanical wounds and inducing physiological modifications in the roots, the nematodes facilitate the rapid entry and systemic spread of the bacteria. This synergy often causes the plant to wilt and die much faster than it would from a single infection, leading to complete crop failure.

118. (C) The interaction is an example of a viral vector mechanism.
The Tundu disease complex is an interaction involving the nematode Anguina tritici and the bacterium Rathayibacter tritici, not a virus. Therefore, statement C is false. The nematode serves as a mechanical transport vector, carrying the bacterial cells on its cuticle as it migrates to the wheat floral primordia. This relationship is a classic example of a nematode-bacterial disease complex where the nematode is essential for the pathogen's dispersal and infection.

119. (A) It kills the insect host and predigests its tissues.
In the mutualistic complex of entomopathogenic nematodes, the bacteria play the primary role in killing the insect host. Once the nematode carries the bacteria into the insect's hemocoel, the bacteria are released and produce potent toxins that cause rapid death. Additionally, the bacteria secrete various enzymes that break down the insect's complex tissues into simpler nutrients, which the nematodes then consume to support their own growth and reproduction.

120. (A) I, II and IV
Statements I, II, and IV are correct: Pasteuria penetrans is an obligate parasite of nematodes, it is a Gram-positive bacterium, and it reproduces by forming highly resistant endospores. Statement III is incorrect because Pasteuria penetrans

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facilitates the fungal invasion of the xylem, leading to severe symptoms in crops like potato, mint, and strawberry.

137. (D) Active trapping
The formation of constricting rings by fungi like Arthrobotrys dactyloides is an example of active trapping. Unlike passive traps that rely on the nematode becoming accidentally stuck, constricting rings actively respond to the presence of prey. Physical contact by a nematode triggers a rapid physiological reaction, causing the ring cells to inflate instantly and cinch around the nematode. This sophisticated mechanical response is one of the most remarkable predatory adaptations found in soil fungi.

138. (C) Chitinase
Chitinase is considered a crucial enzyme for the penetration of nematode eggshells by the biocontrol fungus Purpureocillium lilacinum. Since the structural integrity of nematode eggshells depends largely on a layer of chitin, the production of this enzyme allows the fungus to chemically degrade the shell. This enzymatic action, often working alongside proteases and mechanical pressure, enables the fungal hyphae to enter the egg and consume the developing embryo.

139. (D) Is a strict endoparasite utilizing adhesive spores
Hirsutella rhossiliensis differs from Arthrobotrys oligospora because it is a strict endoparasite that does not form predatory trapping networks. Instead, it produces specialized adhesive conidia that stick to passing nematodes. Once a spore adheres to the cuticle, it germinates and penetrates the host body to complete its life cycle internally. In contrast, Arthrobotrys oligospora can live saprophytically and only forms trapping networks in response to specific environmental cues and the presence of prey.

140. (A) P-II, Q-IV, R-I, S-III
Different nematode genera are specific vectors for various plant viruses. Xiphinema index transmits Grapevine fanleaf virus. Trichodorus vectors are associated with Tobacco rattle virus. Paratrichodorus species are the primary vectors for Pea early-browning virus. Longidorus species, such as L. attenuatus, transmit Tomato black ring virus. These specific pairings are determined by the molecular recognition between the viral coat proteins and the cuticular lining of each nematode's unique feeding apparatus.

141. (A) Synergistic
The interaction between Meloidogyne incognita and Ralstonia solanacearum in tomato is synergistic. The nematode predisposes the plant to bacterial wilt by creating mechanical entry wounds and inducing physiological changes that favor bacterial multiplication. This synergy often leads to the breakdown of bacterial wilt resistance in tomato cultivars, resulting in significantly higher disease incidence and more rapid wilting than would occur if either the nematode or the bacterium infected the plant alone.

142. (B) The bacteria adhere to the nematode cuticle during the J2 stage.
The carriage of Rathayibacter tritici by Anguina tritici occurs because the bacteria adhere securely to the external cuticle of the nematode's infective second-stage juveniles. This mechanical association is highly specific and allows the non-motile bacteria to be transported as the nematodes move from the soil into the developing wheat plant. Once they reach the floral primordia, the bacteria multiply in the presence of the nematodes, leading to the characteristic symptoms of Tundu disease.

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143. (D) Photorhabdus
The bacterial genus Photorhabdus forms a highly specialized mutualistic symbiosis with entomopathogenic nematodes of the genus Heterorhabditis. These bacteria are carried internally by the nematode's infective juvenile stage. When the nematode penetrates an insect host, the bacteria are released into the hemocoel. They produce toxins that rapidly kill the insect and secrete enzymes that digest its tissues, creating a favorable environment for the growth and reproduction of both the bacteria and the nematode.

144. (B) Attachment of the endospore to the cuticle of a moving juvenile
The infection process of Pasteuria penetrans begins when a mature endospore in the soil comes into contact with and attaches to the cuticle of a moving nematode juvenile. This attachment is mediated by specific molecular recognition between the endospore's parasporal fibers and receptors on the nematode's surface. Once the endospore is securely attached, it remains on the

subsequently transmitted to new host plants during the nematode's feeding process.

129. (D) Minimum feeding time required to transmit the virus.
The inoculation threshold period is the minimum amount of time a viruliferous nematode must feed on a healthy host plant to successfully transmit a virus. This period represents the time needed for the nematode to penetrate the plant tissues with its stylet and release the bound viral particles from its feeding apparatus into the host cells. This parameter is critical for understanding the efficiency and speed of virus spread in agricultural systems.

130. (A) Both A and R are true and R is the correct explanation of A.
Plant viruses transmitted by nematodes are indeed lost during the moulting process. This occurs because the viral particles are retained on the internal cuticular lining of the feeding apparatus, which is entirely shed and replaced as part of the exuviae during each moult. Since the viruses do not enter the nematode's internal tissues or replicate inside the body, the newly moulted life stage must re-acquire the virus by feeding on an infected plant.

131. (A) Facilitate pathogen entry via stylet penetration and tissue maceration
Nematodes acting as mechanical vectors for soft-rot bacteria facilitate disease by creating physical entry points in root tissues. Their stylet penetration and the resulting tissue maceration provide pathways for opportunistic bacteria to colonize the host. These bacteria often lack the specialized mechanisms required to penetrate intact plant surfaces. By breaking these physical barriers, nematodes enable the bacteria to invade the plant and cause rapid decay and soft rot symptoms.

132. (A) Nematode-trapping fungi capturing root-knot nematodes
The capture of root-knot nematodes by trapping fungi is an example of an antagonistic interaction. In this relationship, the fungus acts as a predator, using specialized structures to ensnare and consume the nematode. This interaction is detrimental to the nematode population while providing a direct nutritional benefit to the fungus. Such antagonistic relationships are common in the soil rhizosphere and play an important role in the natural biological control of plant-parasitic nematodes.

133. (A) Control the population of pathogenic and saprophytic fungi
The primary ecological function of fungivorous nematodes like Aphelenchus avenae is to graze on soil fungi. By feeding on fungal hyphae, these nematodes help regulate the populations of both pathogenic and saprophytic fungi. This grazing activity is a key component of the soil food web, as it facilitates nutrient mineralization and prevents the overdominance of specific fungal species. In some cases, they can be utilized as biological control agents against soil-borne fungal pathogens.

134. (B) Development of severe symptoms in a resistant cultivar when nematodes are present.
Nematode-induced predisposition is most clearly demonstrated when a plant cultivar with known genetic resistance to a pathogen develops severe disease symptoms following nematode infection. The nematode's activities, such as mechanical wounding and physiological modification of the roots, effectively bypass or suppress the plant's resistance mechanisms. This allows the secondary pathogen, which would normally be unable to infect the cultivar, to successfully colonize the host and cause disease.

135. (A) Giant cells acting as nutrient-rich sinks for fungal hyphae
In the root-knot nematode and Fusarium wilt disease complex, the formation of giant cells is a critical physiological alteration. These specialized cells, induced by the nematode, are metabolically active and act as nutrient-rich sinks that accumulate high concentrations of sugars and amino acids. Fungal hyphae are attracted to these sites and rapidly colonize the giant cells, using the concentrated nutrients to fuel their growth and subsequent invasion of the host's vascular system.

136. (C) Heterodera avenae
Heterodera avenae, the cereal cyst nematode, is not typically associated with a Verticillium wilt disease complex. In contrast, several species of lesion nematodes, such as Pratylenchus penetrans, P. neglectus, and P. thornei, are well-known to interact synergistically with Verticillium dahliae. Their migratory endoparasitic feeding causes extensive root wounding and necrosis, which

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virus remains attached as the nematode moves between plants. When the nematode feeds again, the particles are released into the new host's cells.

153. (B) The specific binding affinity between the viral coat protein and the nematode cuticular lining
In non-moulting adult vector nematodes, the duration of viral retention is primarily dictated by the specific binding affinity between the viral coat protein and the nematode's cuticular lining. This molecular interaction determines how securely the viral particles are held within the feeding apparatus. Stronger binding leads to longer retention periods, sometimes lasting several months. This relationship is highly specific for each virus-vector pair, ensuring efficient transmission within their respective host ranges.

154. (C) Mechanical facilitation
The relationship where nematode wounds facilitate the entry of opportunistic rotting microorganisms is termed mechanical facilitation. In this interaction, the nematode's physical activities—such as stylet penetration and migration—create breaches in the plant's protective barriers. These entry points allow bacteria and fungi, which lack independent mechanisms to penetrate healthy roots, to colonize and rot the tissues. This relationship is mechanical because it does not involve an evolved, obligate biological dependency between the organisms.

155. (D) Amensalism
Amensalism is an ecological interaction characterized by a neutral outcome for one organism and a detrimental or inhibitory outcome for the other. In the rhizosphere, this occurs when one organism produces a metabolic byproduct, such as a toxin or antibiotic, that suppresses the growth or activity of a nematode population. The organism producing the substance gains no direct benefit from the nematode's suppression, making the relationship asymmetrical in its impact on the two species.

156. (B) Grazing on bacteria and excreting excess nitrogen as ammonia
Bacterivorous nematodes aid in plant nutrition primarily by grazing on soil bacteria and excreting the excess nitrogen as ammonium. Because bacteria have a lower carbon-to-nitrogen ratio than the nematodes that consume them, the nematodes must void the surplus nitrogen to maintain their internal metabolic balance. This process, known as nutrient mineralization, increases the concentration of inorganic nitrogen in the soil, making it readily available for root uptake and enhancing plant growth.

157. (B) Nematode-induced predisposition
The breakdown of genetic resistance in tomato to Fusarium wilt due to root-knot nematode infection is a classic example of nematode-induced predisposition. The presence of Meloidogyne species alters the physiological and structural integrity of the tomato roots, allowing the fungus to bypass the plant's natural resistance mechanisms. This interaction effectively makes a normally resistant cultivar susceptible to the disease, leading to severe wilting and crop damage that would not occur in the absence of nematodes.

158. (B) Giant cells
In the Meloidogyne and Fusarium wilt disease complex, the fungal pathogen often rapidly colonizes the specialized giant cells induced by the nematode. These cells are metabolically highly active and serve as nutrient-rich sinks, accumulating sugars and amino acids. The concentrated nutrients provide an ideal environment for the growth and multiplication of Fusarium oxysporum. Once the fungus establishes itself in the giant cells, it can easily spread into the host's vascular system.

159. (A) Early dying syndrome in potatoes
The synergistic interaction between Pratylenchus penetrans and Verticillium dahliae typically leads to "early dying syndrome" in potatoes. The migratory endoparasitic feeding of the lesion nematode causes extensive root wounding and necrosis, which facilitates the rapid entry and spread of the vascular fungal pathogen. This combined stress results in premature senescence, severe wilting, and significant yield reductions. The disease complex is much more destructive than infections by either the nematode or the fungus alone.

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cuticle until it germinates and forms a germ tube that penetrates the nematode's body.

145. (A) Enhanced plant growth despite the presence and feeding of nematodes
AMF-mediated plant tolerance is characterized by the plant's ability to maintain relatively high growth and yield levels despite being infected by parasitic nematodes. This tolerance is achieved through improved host vigor, enhanced phosphorus acquisition, and the activation of systemic defense pathways. While the nematodes may still be present and feeding, the mycorrhizal symbiosis helps the plant compensate for the loss of root biomass and physiological stress, resulting in better overall performance.

146. (D) Arbuscules
Arbuscules are the primary structural features of Arbuscular Mycorrhizal Fungi involved in nutrient exchange within host root cells. These highly branched hyphal structures develop within the cortical cells, providing a large surface area for the transfer of minerals, especially phosphorus, to the plant and host-derived carbon to the fungus. Arbuscules are also the main sites of spatial competition with sedentary nematodes, as both organisms require the same cortical cells to establish their specialized structures.

147. (B) Competition for specific cellular feeding sites (syncytia vs. giant cells)
During interspecific competition between Meloidogyne and Heterodera, population suppression is primarily driven by competition for specialized cellular feeding sites within the vascular cylinder. Meloidogyne species induce giant cells, while Heterodera species establish syncytia. Since both genera require these metabolically active sites to develop and reproduce, their simultaneous presence in the same root zone leads to competition for available vascular tissue and host carbon, often resulting in the suppression of one species.

148. (D) Seinurids
Seinurids are a group of predatory nematodes that possess a functional, hollow stylet. They use this specialized structure to pierce the cuticle of their prey, typically other soil nematodes, and inject potent, paralyzing secretions. Once the prey is immobilized, the predator uses the stylet to suck out the internal body contents. This rapid and efficient killing mechanism allows seinurids to act as effective predators, often attacking and consuming organisms much larger than themselves.

149. (B) A long, hollow axial odontostyle
The family Longidoridae is distinguished from Trichodoridae by several morphological features, most notably the presence of a long, hollow axial odontostyle. This feeding spear is used to penetrate deep into root tissues to feed on specialized host cells. In contrast, Trichodoridae nematodes possess a solid, curved feeding spear called an onchiostyle. These structural differences reflect their different taxonomic positions and their specific evolutionary adaptations for feeding and virus transmission in various soil environments.

150. (A) II
Statement II is incorrect because Nepoviruses are not transmitted by Trichodorus; they are vectored exclusively by nematodes in the family Longidoridae, specifically the genera Xiphinema and Longidorus. Statements I, III, IV, and V are correct: Nepoviruses have isometric particles, they include Grapevine fanleaf virus, they are transmitted by Xiphinema, and they are retained on the cuticular lining of the odontostyle or odontophore within the nematode's feeding apparatus.

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151. (C) Xiphinema - Nepoviruses
The combination of Xiphinema and Nepoviruses is a well-established and correct virus-vector pairing. Genera within the family Longidoridae, particularly Xiphinema and Longidorus, are the only known nematode vectors for Nepoviruses. For example, Xiphinema index is the primary vector for Grapevine fanleaf virus. Other combinations are incorrect; Tobraviruses are transmitted by Trichodoridae, not Longidoridae, and Luteoviruses are typically transmitted by insect vectors like aphids rather than soil-dwelling nematodes.

152. (B) Cuticular lining of the internal pharyngeal tract.
In Paratrichodorus species, the specific site for viral retention is the cuticular lining of the internal pharyngeal tract, which includes the onchiostyle and the pharynx. During feeding on an infected host, viral particles like Tobacco rattle virus adhere to this lining. The molecular specificity of this binding ensures that the

168. (B) By colonizing cortical cells required for feeding sites
Arbuscular Mycorrhizal Fungi structurally compete with endoparasitic nematodes by colonizing the same cortical cells that the nematodes require to establish their feeding sites. AMF form arbuscules within these cells for nutrient exchange with the plant. Since there is limited space and host carbon available within the root cortex, the establishment of the fungal symbiont can restrict the number and size of feeding sites that nematodes, such as root-knot or cyst species, can successfully instruct.

169. (B) Enhanced plant tolerance to the nematode damage
A common outcome when Meloidogyne and Glomus species co-occur on a host plant is enhanced plant tolerance to nematode damage. The mycorrhizal fungus improves the host's overall vigor and phosphorus nutrition, which allows the plant to compensate for root loss and metabolic stress caused by the nematodes. Furthermore, AMF colonization can induce systemic defense responses and alter root exudation patterns, making the entire root system less susceptible to extensive nematode colonization and reproduction.

170. (C) A is true but R is false.
Assertion A is true: interspecific competition between Meloidogyne and Heterodera often results in niche partitioning as they vie for root resources. However, Reason R is false because the two genera do not require identical feeding structures. Meloidogyne induces giant cells, whereas Heterodera forms syncytia. While both occupy the vascular cylinder, their biological mechanisms for establishing feeding sites are distinct, and competition arises from their shared requirement for space and host-derived carbon.

171. (B) Mononchus
Mononchus is a genus of predatory nematodes easily identified by its large, barrel-shaped buccal cavity, which is heavily sclerotized. This stoma is typically equipped with a prominent dorsal tooth, and some species may also have smaller subventral teeth or denticles. These morphological features are adaptations for an active predatory lifestyle, allowing the nematode to grasp and puncture its prey. Mononchids are common in diverse soil environments and play a role in regulating nematode populations.

172. (A) Xiphinema and Longidorus
The Order Dorylaimida includes two important virus-vectoring genera: Xiphinema and Longidorus. These nematodes are relatively large and possess a long, hollow axial odontostyle used for feeding on plant roots. They are the only known vectors for Nepoviruses, such as Grapevine fanleaf virus and Tomato black ring virus. They acquire these viruses during feeding and retain the particles on the cuticular lining of their feeding apparatus, facilitating the spread of viral diseases in various crops.

173. (A) Isometric (spherical)
Nepoviruses are characterized by their isometric, or spherical, viral particle morphology. These particles are typically about 28 to 30 nanometers in diameter and contain a bipartite RNA genome. This distinct shape distinguishes them from other nematode-transmitted viruses, such as Tobraviruses, which have rod-shaped particles. Nepoviruses are vectored exclusively by nematodes in the family Longidoridae, which retain the spherical particles on specific cuticular binding sites within their feeding apparatus.

174. (A) Tobacco rattle virus (TRV) - Trichodorus
The combination of Tobacco rattle virus and Trichodorus is a correctly matched virus-vector pair. TRV is a Tobravirus that is specifically transmitted by nematodes in the family Trichodoridae, which includes the genus Trichodorus. These nematodes acquire the rod-shaped viral particles during feeding and retain them on the cuticular lining of their pharynx and onchiostyle. Other listed combinations are incorrect, as different virus-vector specificities exist for Nepoviruses and their respective dorylaimid vectors.

175. (A) The inner surface of the odontostyle
In the functional anatomy of Longidorus nematodes, viral particles are specifically found attached to the inner surface of the odontostyle lining. This location serves as the retention site for Nepoviruses acquired from infected plants. The molecular recognition between the viral coat protein and this cuticular surface ensures that the virus remains bound as the nematode moves through the soil. During subsequent feeding on a healthy host, the particles are released and inoculated into the plant tissue.

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176. (B) Shedding of the cuticular lining where the virus is retained
The loss of viral infectivity in nematodes after moulting is caused by the shedding of the cuticular lining of the feeding apparatus. Viral particles are retained on these internal surfaces, which are entirely replaced during each moult. Since the viruses do not enter the nematode's body tissues or replicate internally, they are lost along with the old cuticle. The nematode must feed on an infected plant again to re-acquire the virus in its new life stage.

177. (B) Agents that create physical pathways for fungal infection through wounding
Nematodes that function as mechanical vectors for secondary opportunistic fungi are agents that create physical pathways for infection. Their stylet penetration and migratory activities result in numerous wounds and macerated tissues within the root system. These entry points are exploited by soil-borne fungi that lack the ability to penetrate healthy, intact plant surfaces. By breaking these physical barriers, the nematodes facilitate the colonization of the host, often leading to more severe decay and root rot.

178. (B) One organism benefits while the other is unaffected.
Commensalism occurs in the rhizosphere when one organism benefits from the activities of another without causing any harm or providing any benefit in return. For example, some soil bacteria may utilize the specialized exudates or necrotic tissues produced by nematode feeding as a nutrient source. While the bacteria gain a clear advantage for growth and reproduction, the nematode population remains largely unaffected by their presence, making the ecological relationship asymmetrical and non-detrimental to the host.

179. (B) Feeding on primary decomposers like bacteria and fungi
Non-parasitic nematodes, such as bacterivores and fungivores, contribute to nutrient mineralization primarily by grazing on the primary decomposers in the soil. These nematodes consume bacteria and fungi that have already sequestered nutrients from organic matter. As the nematodes digest this microbial biomass, they excrete the excess nitrogen and other minerals back into the soil as inorganic compounds like ammonium. This process makes these essential nutrients once again available for plant root uptake and growth.

180. (A) P-II, Q-III, R-IV, S-I
Different disease complexes involve specific nematode-pathogen pairings. Fusarium wilt is often exacerbated by Meloidogyne incognita. Verticillium wilt in potato is synergistically linked with Pratylenchus penetrans. Bacterial wilt caused by Ralstonia is frequently associated with Meloidogyne javanica and other root-knot species. Yellow ear rot, or Tundu disease of wheat, uniquely involves Anguina tritici as its vector. These interactions demonstrate the diverse ways nematodes interact with other pathogens to influence the severity and spread of plant diseases.

181. (A) Alteration of physiology and compromise of defense barriers.
The fundamental mechanism behind nematode-induced predisposition is the alteration of the host plant's physiology and the compromise of its physical and chemical defense barriers. Nematode infection induces specialized feeding sites and causes mechanical wounding, which leads to the leakage of nutrients and suppression of natural defense responses. These changes create a highly favorable environment for secondary soil pathogens, allowing them to overcome host resistance and establish infections that would otherwise be unsuccessful.

182. (B) More severe symptoms than the sum of their individual effects
A synergistic relationship between Meloidogyne and Fusarium is characterized by disease symptoms that are much more severe than the sum of the damage caused by either pathogen alone. The nematode predisposes the plant to fungal infection by creating entry wounds and inducing metabolic changes in the roots. This synergy can result in the rapid wilting and death of the host, often leading to total crop failure in fields where both the nematode and fungus are present.

183. (A) Migratory endoparasitism causing extensive cortical necrosis
In the Pratylenchus and Verticillium disease complex, the migratory endoparasitic feeding behavior of the lesion nematode is the primary factor facilitating the interaction. As the nematodes move through the root cortex, they

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cause extensive mechanical wounding and tissue necrosis. These damaged areas serve as ideal entry points for the fungal pathogen Verticillium dahliae. The resulting synergy leads to severe blockage of the xylem and premature senescence of the plant, especially in potato crops.

184. (A) A three-celled ring that inflates rapidly upon stimulation
The trap formation mechanism in Arthrobotrys dactyloides involves a specialized three-celled ring structure. When a nematode attempts to crawl through the ring, the physical contact triggers a rapid physiological response. The cells of the ring expand inward almost instantly due to a sudden increase in turgor pressure, cinching the ring around the nematode's body and trapping it securely. Once ensnared, the fungus produces hyphae that penetrate and consume the internal tissues of the prey.

185. (D) Purpureocillium lilacinum
Purpureocillium lilacinum is a well-known egg-parasitizing fungus used in the biological control of plant-parasitic nematodes. It colonizes the rhizosphere and specifically targets the egg masses of root-knot and cyst nematodes. The fungus utilizes a combination of mechanical force and specialized enzymes, like chitinases, to penetrate the eggshell and consume the developing embryo. By destroying the next generation of nematodes before they hatch, it effectively reduces the population density in infested soils.

186. (D) Hirsutella rhossiliensis
Hirsutella rhossiliensis is an endoparasitic fungus that utilizes specialized adhesive conidia to infect motile nematodes. These sticky spores are produced on phialides and adhere to the cuticle of any nematode that comes into contact with them. Once attached, the spore germinates and penetrates the nematode's body wall. The fungus then grows internally, filling the host with mycelia and eventually producing new spores on the surface of the dead carcass to continue the infection cycle.

187. (D) All of the above are susceptible hosts
The synergistic complex between Meloidogyne species and the bacterial wilt pathogen Ralstonia solanacearum is devastating across a wide range of important agricultural crops, including potato, tomato, and tobacco. In all these hosts, the nematodes provide essential entry wounds and induce physiological modifications that facilitate the rapid colonization of the vascular system by the bacteria. This widespread susceptibility makes the management of root-knot nematodes critical for controlling bacterial wilt in diverse farming systems.

188. (B) Carriage on the cuticle of actively migrating Anguina tritici juveniles
In the Tundu disease complex, the non-motile Rathayibacter tritici bacteria reach the floral primordia of wheat by being carried on the cuticle of actively migrating Anguina tritici juveniles. This mechanical transport is essential because the bacteria lack independent motility to reach the target tissue. As the nematodes move from the soil through the plant to reach the developing ear, they carry the bacteria along, enabling the massive multiplication that causes the characteristic yellow slime symptoms.

189. (C) I and II
Statements I and II are correct: Steinernema nematodes are mutualistically associated with Xenorhabdus bacteria, while Heterorhabditis species are associated with Photorhabdus. Statement III is incorrect because entomopathogenic nematodes are not plant parasites; instead, they are beneficial soil organisms that parasitize and kill a wide range of insect pests. Their symbiosis with specific bacteria is essential for their ability to successfully infect and reproduce within the insect host.

190. (A) I, III, II, IV
The typical sequence of an AMF-nematode interaction leading to tolerance begins with the colonization of the root cortex by the fungus (I). This colonization leads to enhanced plant phosphorus uptake and overall vigor (III). When nematodes later penetrate the root (II), the plant is better able to withstand the infection. The final result is the mitigation of nematode-induced stress (IV), allowing the host to maintain growth and yield despite the presence of the parasites.

191. (D) Both A and C
Pasteuria penetrans pathogenesis is severely hindered if the nematode is already a sedentary adult female, as the infection typically requires attachment to a motile juvenile stage to progress effectively. Furthermore, if the nematode cuticle lacks the specific receptors required

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for the endospore's parasporal fibers to bind, the infection cannot even be initiated. Both of these factors reflect the highly specialized and stage-specific nature of this obligate bacterial parasite's life cycle in the soil.

192. (A) Glomus (Rhizophagus)
Genera such as Glomus, now often classified as Rhizophagus, are the most frequently cited Arbuscular Mycorrhizal Fungi in studies involving plant tolerance to root-knot nematodes. These fungi are widespread and form highly efficient symbiotic relationships with many important crop plants. By improving nutrient acquisition and inducing systemic defense pathways, Glomus species help their hosts better withstand the damage and physiological stress caused by Meloidogyne species, often leading to improved agricultural yields.

193. (D) Root cortex
Spatial competition between Arbuscular Mycorrhizal Fungi and sedentary nematodes primarily involves the limited space within the root cortex. This tissue is essential for both organisms; AMF form arbuscules for nutrient exchange, while nematodes establish specialized feeding sites like giant cells or syncytia. Because both require cortical cells and compete for the same host-derived carbon resources, the presence of one often limits the establishment and growth of the other within the same root system.

194. (A) Asymmetrical reduction in the population of one species
Interspecific competition among plant-parasitic nematodes, such as that between root-knot and lesion nematodes, typically results in an asymmetrical reduction in the population of one species. This occurs as they vie for limited resources like feeding sites and host nutrients within the root system. The species that colonizes the root first or is better adapted to the specific host environment often gains a competitive advantage, leading to the suppression of the other population's reproduction and growth.

195. (A) It possesses a small stoma and often feeds on bacteria as well as nematodes.
Predatory nematodes in the genus Diplogaster are characterized by a relatively small stoma and an opportunistic feeding habit. They are not obligate predators and often feed on bacteria, yeasts, and other small soil organisms in addition to smaller nematodes. Some species may develop more specialized mouthparts when prey is abundant, but they generally maintain a more diverse diet compared to the large-toothed mononchids. They are frequently found in environments rich in decaying organic matter.

196. (C) A solid, curved onchiostyle
The family Trichodoridae is taxonomically characterized by the presence of a solid, curved feeding spear called an onchiostyle. This structure is used by these nematodes, commonly known as stubby-root nematodes, to feed on the external cells of root tips. Members of this family, including the genera Trichodorus and Paratrichodorus, are economically important because they are the exclusive vectors for Tobraviruses, such as Tobacco rattle virus, which they transmit during their ectoparasitic feeding.

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197. (A) Grapevine fanleaf virus
Grapevine fanleaf virus is specifically transmitted by the dagger nematode Xiphinema index. This nematode acquires the virus from infected grapevines and retains it at specific binding sites within the cuticular lining of its odontophore and esophageal bulb. Xiphinema index is the most significant vector for this virus worldwide, and its presence in vineyards is a major concern for grape growers, as it facilitates the spread of this debilitating disease through the soil.

198. (B) Trichodoridae
Tobraviruses are transmitted exclusively by nematodes belonging to the family Trichodoridae. This family includes the genera Trichodorus and Paratrichodorus, which are migratory ectoparasites. These nematodes possess a unique solid feeding spear, the onchiostyle, and they retain viral particles on the cuticular lining of their pharynx. This group of viruses includes several significant plant pathogens, such as Tobacco rattle virus, which can cause severe disease in a wide variety of crop and ornamental plants.

199. (A) Odontophore lining and esophageal bulb
In the genus Xiphinema, viral particles are specifically retained on the cuticular lining of the odontophore and the esophageal bulb. These anatomical regions provide the necessary binding sites for Nepoviruses acquired during feeding. The specificity of this molecular interaction ensures that only certain viruses are successfully

vectored by each nematode species. Because the retention sites are part of the internal feeding apparatus, the bound viral particles are lost each time the nematode undergoes a moult.

200. (C) A is true but R is false.
Assertion A is true: nematode-transmitted viruses are considered non-persistent or semi-persistent because they are lost during the moulting process and do not persist through the vector's entire life cycle. However, Reason R is false because these viruses do not replicate inside the nematode vector. Instead, they simply adhere to the cuticular lining of the feeding apparatus and are transmitted mechanically between host plants without any internal biological multiplication or circulation.

201. (A) Inoculation access period (IAP)
The inoculation access period refers to the minimum time a viruliferous nematode must feed on a healthy host plant to successfully transmit a virus. This period represents the duration required for the nematode to penetrate the plant tissues with its stylet and release the bound viral particles from its feeding apparatus into the host cells. Understanding the IAP is critical for determining how quickly a virus can spread within a field through its nematode vector.

202. (B) Mechanical vectoring and tissue maceration by nematodes
The presence of secondary opportunistic rotting microorganisms in nematode-damaged tissues is a consequence of mechanical vectoring and tissue maceration. Nematodes create numerous physical wounds and areas of damaged tissue through their feeding and migratory activities. These entry points allow soil-borne bacteria and fungi, which lack independent mechanisms to penetrate healthy roots, to colonize and rot the plant tissues. This relationship is mechanical, as the pathogens exploit the damage caused by the nematodes.

203. (C) Competition
Competition occurs when two nematode populations utilize the same limited root resources, such as feeding sites or host nutrients, leading to mutual suppression. This interspecific interaction is common in agricultural soils where multiple nematode genera are present. As they vie for space and carbon within the root system, their reproduction and overall population growth are often reduced compared to single-species infections. This competitive pressure can influence the long-term population dynamics of both nematode species.

204. (D) The carbon-to-nitrogen (C:N) ratio and nutrient mineralization in soil
By grazing on microbial biomass, bacterivorous and fungivorous nematodes directly influence the soil carbon-to-nitrogen ratio and accelerate the process of nutrient mineralization. These nematodes consume microorganisms that contain more nitrogen than they require for their own metabolism. The excess nitrogen is excreted back into the soil as ammonium, converting organic nutrients into inorganic forms that plants can easily absorb. This grazing activity is a fundamental driver of nutrient cycling and soil fertility.

205. (A) Genetic resistance and physical/chemical barriers to secondary pathogens
Nematode-induced predisposition is fundamentally a disruption of the host plant's genetic resistance and its physical and chemical barriers. Nematode infection causes mechanical wounding and induces physiological changes that suppress the plant's natural defense responses. These alterations create a more favorable environment for secondary soil pathogens to establish infection. Consequently, a normally resistant cultivar may become susceptible to disease, demonstrating how nematodes can fundamentally compromise the plant's ability to defend itself against other pathogens.

206. (A) High accumulation of nutrients and specialized carbohydrates
A key physiological change in giant cells that favors Fusarium oxysporum colonization is the high accumulation of nutrients and specialized carbohydrates. These metabolically active cells, induced by root-knot nematodes, act as major nutrient sinks within the root. The concentrated sugars and amino acids provide a rich food source that stimulates rapid fungal growth and multiplication. Once the fungus colonizes these sites, it can easily spread into the vascular system, leading to severe wilting symptoms.

207. (A) Their destructive migratory endoparasitic feeding habit
Pratylenchus species are highly effective at inciting disease complexes because of their

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253. (A) Physiological stress, root wounding, and leakage of exudates
Nematode-induced predisposition is primarily driven by physiological stress, root wounding, and the subsequent leakage of host exudates. As nematodes feed and migrate, they cause physical damage and induce metabolic changes that weaken the plant's natural defenses. The leakage of sugars and amino acids from the wounded roots attracts secondary pathogens like Fusarium or Verticillium. These changes create a highly favorable environment for pathogens to overcome host resistance and establish infection more effectively than in healthy roots.

254. (C) Nematode infection precedes or coincides with fungal infection.
In the Meloidogyne-Fusarium complex, the breakdown of resistance is most severe when nematode infection precedes or coincides with fungal infection. This timing allows the nematode to initiate the physiological modifications and mechanical wounding necessary to predispose the host roots. By the time the fungus attempts to colonize the plant, the defenses are already compromised and the tissues are modified to support rapid fungal growth, leading to much more severe wilting symptoms and faster plant death.

255. <ENO> 255 (A) Creates extensive necrotic lesions that serve as entry courts
Pratylenchus penetrans acts synergistically with Verticillium dahliae because its migratory endoparasitic feeding behavior creates extensive necrotic lesions in the root cortex. As these lesion nematodes move through the tissues, they cause widespread mechanical damage and cell death. These lesions serve as highly effective entry courts for the fungal pathogen, allowing it to bypass the plant's outer defenses and rapidly reach the vascular system. This synergy leads to the devastating "potato early dying" syndrome.

256. (B) Carbon is scarce and nematode presence is detected
Arthrobotrys oligospora transitions to a predatory lifestyle and forms adhesive networks primarily when carbon resources are scarce and the presence of nematode prey is detected. Environmental signals, such as nematode-produced pheromones called ascarosides, act as cues for the fungus to switch from saprophytic growth to trap formation. This adaptive response allows the fungus to obtain essential nitrogen and other nutrients from the captured nematodes, ensuring its survival and growth in nutrient-limited soil conditions.

257. (B) It is a potent parasite of nematode eggs and sedentary females.
A definitive characteristic of Purpureocillium lilacinum is its role as a potent parasite of nematode eggs and sedentary females. It is a widespread soil fungus that colonizes the gelatinous matrix of root-knot and cyst nematode egg masses. The fungus utilizes mechanical pressure and specialized enzymes, including proteases and chitinases, to penetrate the eggshell and consume the developing embryo. This ability makes it one of the most important and commercially utilized biocontrol agents for managing plant-parasitic nematode populations.

258. (D) I, II and III
All three statements regarding endoparasitic fungi are correct. Catenaria anguillulae utilizes motile zoospores to find and infect its hosts. Hirsutella rhossiliensis uses adhesive conidia that stick to passing nematodes. Furthermore, these fungi are characterized by developing their vegetative mycelium primarily within the body of the nematode, consuming its internal tissues to support their own reproduction. These internal life cycles are highly specialized adaptations for parasitizing various stages of soil-dwelling nematodes.

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259. (A) They provide entry wounds and alter host physiology, exacerbating bacterial wilt.
Meloidogyne species play a crucial role in the synergistic disease complex with Ralstonia solanacearum by providing essential mechanical entry wounds and altering host physiology. The nematode's feeding and gall formation create pathways for the bacteria to enter the vascular system and induce metabolic changes that favor bacterial multiplication. These activities effectively suppress the plant's natural resistance, leading to a much more rapid and severe expression of bacterial wilt symptoms than would occur with the bacteria alone.

260. (A) P-II, Q-III, R-I, S-IV
Many soil-borne disease complexes involve specific pairings of nematodes and other pathogens. Tundu disease of wheat is caused by Anguina and Rathayibacter (P-II). Potato early dying involves

215. (B) An endospore adheres to the cuticle of a susceptible nematode
Pasteuria penetrans pathogenesis begins when a mature endospore in the soil comes into contact with and adheres to the external cuticle of a susceptible nematode. This attachment is a highly specific molecular process involving recognition between the endospore's parasporal fibers and receptors on the nematode's surface. Once the spore is securely attached, it remains on the cuticle as the nematode moves through the soil, eventually germinating and penetrating the host body to begin the infection.

216. (B) It causes increased lignification and altered root exudation patterns.
Arbuscular Mycorrhizal Fungi colonization alters the host root system in several ways that affect nematode invasion. It often leads to increased lignification of cell walls, which can physically impede nematode penetration and migration. Additionally, AMF change the profile of root exudates released into the rhizosphere, which can reduce the attraction of nematode juveniles to the roots. These structural and biochemical modifications help the plant better defend itself against the initial stages of nematode infection.

217. (A) The root cortex for arbuscule and giant cell formation
Spatial competition between Glomus species and Meloidogyne occurs because both organisms require access to the root cortex to establish their specialized structures. AMF form arbuscules within cortical cells for nutrient exchange, while root-knot nematodes induce the formation of giant cells in the same tissue region. Because the amount of cortical space and host-derived carbon is limited, the simultaneous presence of both organisms often leads to competition and mutual suppression of their development.

218. (A) Pratylenchus causes cortical necrosis, destroying the resources needed for giant cells.
When Meloidogyne incognita and Pratylenchus penetrans co-infect a root, their competition is driven by the destructive behavior of the lesion nematode. Pratylenchus is a migratory endoparasite that causes extensive necrosis and tissue maceration as it moves through the root cortex. This destruction can physically eliminate the cortical resources and cell populations that Meloidogyne needs to induce and maintain its specialized giant cell feeding sites, thereby suppressing the root-knot nematode's reproduction and success.

219. (C) A heavily cuticularized stoma with a large dorsal tooth
Mononchids are effective predatory nematodes primarily due to their large, barrel-shaped buccal cavity, or stoma, which is heavily cuticularized. This stoma is typically equipped with one or more prominent teeth, used to grasp and puncture the cuticle of other soil organisms. This robust mouthpart allows them to consume smaller nematodes whole or suck out the internal contents of larger prey, making them important natural regulators of diverse nematode populations in healthy soil ecosystems.

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220. (B) Dorylaimida
The nematode family Longidoridae belongs to the taxonomic Order Dorylaimida. This order is characterized by the presence of a specialized feeding spear called an odontostyle. Members of this family, including the genera Xiphinema and Longidorus, are significant because they are the only known vectors for Nepoviruses. They acquire these viruses during their ectoparasitic feeding on plant roots and retain them on the cuticular lining of their feeding apparatus, facilitating the spread of viral diseases.

221. (D) Xiphinema
The genus Xiphinema is not classified under the family Trichodoridae; instead, it belongs to the family Longidoridae within the Order Dorylaimida. The family Trichodoridae includes the genera Trichodorus and Paratrichodorus, which are characterized by their solid, curved onchiostyle. While both families contain virus-vectoring nematodes, they transmit different groups of viruses and belong to distinct taxonomic orders, reflecting significant differences in their anatomy, evolutionary history, and specific ecological roles in the soil.

222. (A) Odontophore lining
The transmission of Nepoviruses by Xiphinema species requires that the viral particles attach specifically to the cuticular lining of the odontophore and the esophageal bulb. These anatomical sites provide the necessary molecular environment for the virus to bind securely after being acquired from an infected plant. This specific retention ensures that the virus is carried by the nematode as it moves to a new host, where

destructive migratory endoparasitic feeding habit. Unlike sedentary nematodes that remain in one place, lesion nematodes move continuously through the root cortex, causing extensive mechanical wounding and tissue necrosis. These large areas of damaged tissue serve as ideal entry points for opportunistic soil fungi and bacteria. This continuous wounding significantly increases the plant's susceptibility to secondary infections and severe root rot diseases.

208. (A) Adhesive branches or knobs
Fungi in the genus Monacrosporium typically capture soil nematodes using specialized adhesive structures, such as sticky branches or adhesive knobs. These traps are produced on the fungal hyphae and are coated with a powerful adhesive substance that ensnares any nematode that comes into contact with them. Once the prey is trapped, the fungus produces infection pegs that penetrate the cuticle, allowing the mycelia to grow internally and digest the nematode's tissues for nutrients.

209. (B) Enzymatically penetrating and digesting eggs
Pochonia chlamydosporia reduces nematode populations primarily by enzymatically penetrating and digesting the eggs. This biocontrol fungus colonizes the rhizosphere and the gelatinous matrix of root-knot and cyst nematode egg masses. It utilizes a combination of mechanical pressure and specialized enzymes, including proteases and chitinases, to break through the eggshell. Once inside, the fungus consumes the developing embryo, effectively preventing the completion of the life cycle and reducing the overall nematode population density.

210. (B) P-I, Q-II, R-III, S-IV
Different types of soil nematodes play distinct ecological roles. Bacterivores graze on bacteria and release nitrogen (P-I), while fungivores regulate fungal growth by grazing on hyphae (Q-II). Predators feed on other nematodes, serving as natural biocontrol agents (R-III). Plant-parasites act as primary pests by consuming root cytoplasm (S-IV). These diverse feeding groups interact within the soil food web to influence nutrient cycling, microbial community structure, and the health of agricultural crops.

211. (C) Endoparasites infecting motile stages
Catenaria anguillulae is an endoparasitic fungus that specifically infects the motile stages of nematodes. It utilizes flagellated zoospores that move through soil water to find a host. The zoospores encyst near natural body orifices and germinate, sending infection hyphae into the nematode's body. Once inside, the fungus develops its vegetative mycelia within the host, eventually consuming all internal tissues. This internal development is characteristic of endoparasitic fungi that target active soil organisms.

212. (A) Creating mechanical wounds and altering root physiology for bacterial entry
In the synergistic complex between Meloidogyne and Ralstonia solanacearum, the primary role of the nematode is to facilitate the entry and establishment of the bacteria. The nematode's feeding creates mechanical wounds in the root and induces physiological changes that suppress the host's natural defenses. These alterations provide the bacteria with easy access to the vascular system and a more favorable environment for multiplication, leading to more severe and rapid development of bacterial wilt symptoms.

213. (A) Ear cockle and yellow ear rot (Tundu)
Anguina tritici and Rathayibacter tritici work together to cause two distinct diseases in wheat: ear cockle and yellow ear rot, also known as Tundu. The nematode alone causes the formation of dark galls, or cockles, in place of wheat kernels. However, when the nematode acts as a vector for the bacterium, the bacteria multiply rapidly at the plant apex, leading to the characteristic yellow slime and distorted heads associated with Tundu disease.

214. (C) Produce toxins that kill the insect and enzymes that break down its tissues
The mutualism between entomopathogenic nematodes and their bacteria relies on the bacteria's ability to produce potent toxins and enzymes. Once the nematode carries the bacteria into an insect host's hemocoel, the bacteria are released and rapidly kill the insect. The enzymes then digest the insect's complex tissues into a nutrient-rich soup. This process provides the essential nutrients required for the growth and reproduction of both the bacterial population and the nematode vector.

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acquired and retained at specific binding sites in the feeding apparatus (II). The viruliferous nematode then migrates through the soil to a healthy plant (III). Finally, the virus is inoculated into the new host when the nematode begins feeding (IV). This process ensures the efficient spread of viruses within a susceptible crop.

231. (B) Synergism
The disease complex involving root-knot nematodes and Fusarium oxysporum is a classic example of synergism. In this relationship, the combined impact of the two pathogens on the host plant is significantly greater than the sum of their individual effects. The nematode predisposes the plant to fungal infection by creating entry wounds and inducing physiological changes that favor the fungus. This results in more severe wilting and rapid plant death than either pathogen could cause alone.

232. (B) Acting as vectors and causing extensive root necrosis that facilitates fungal entry
Pratylenchus species increase the severity of Verticillium wilt by acting as mechanical facilitators. Their migratory endoparasitic feeding causes extensive root necrosis and mechanical wounding as they move through the cortex. These damaged areas provide numerous entry courts for the fungal pathogen Verticillium dahliae, which would otherwise struggle to penetrate intact roots. Once inside, the fungus colonizes the vascular system, and the synergistic action with the nematode leads to severe "early dying" symptoms in host plants.

233. (B) Constricting rings
Arthrobotrys dactyloides is a specialized predatory fungus characterized by its ability to capture soil nematodes using constricting rings. These rings consist of three specialized cells that respond to physical contact. When a nematode attempts to move through the ring, the cells rapidly inflate due to a sudden increase in turgor pressure, trapping the prey securely. After capture, the fungus produces infection hyphae that penetrate and consume the internal tissues of the nematode as a source of nutrients.

234. (A) Rapidly colonizes and destroys nematode eggs
Purpureocillium lilacinum is a highly effective biocontrol agent because it rapidly colonizes and destroys the eggs of plant-parasitic nematodes. It is an opportunistic fungus that targets the sedentary stages of root-knot and cyst nematodes. By enzymatically penetrating the eggshell and consuming the developing embryo, it prevents the next generation of nematodes from hatching. Its ability to grow in the rhizosphere and specifically attack reproductive structures makes it a valuable tool for managing nematode populations in agricultural fields.

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235. (B) Adhesive conidia adhering to the passing nematode cuticle
The primary mode of infection for Hirsutella rhossiliensis involves specialized adhesive conidia. These sticky spores are produced on phialides and remain attached to the fungal mycelium in the soil. When a nematode passes by and makes contact with the spores, they adhere firmly to its cuticle. The spores then germinate and send infection tubes through the body wall. The fungus grows internally, eventually filling the entire host with mycelia and consuming its internal tissues to produce more spores.

236. (B) Accelerated and increased the severity of fungal symptoms.
Atkinson originally described the cotton wilt complex by observing that the presence of root-knot nematodes significantly accelerated and increased the severity of symptoms caused by the Fusarium fungus. He noted that even in cultivars with some resistance to the fungus, the nematode's activities made the plants much more susceptible. This early observation laid the foundation for our understanding of synergistic disease complexes, where one pathogen predisposes the host to another, leading to more devastating crop damage.

237. (A) Cuticular surface of the second-stage juvenile (J2)
In the Tundu disease complex of wheat, the physical association between Anguina tritici and Rathayibacter tritici occurs primarily on the cuticular surface of the nematode's infective second-stage juvenile. The non-motile bacteria adhere securely to the nematode's body, allowing them to be transported from the soil into the developing floral tissues as the nematode migrates through the plant. This mechanical carriage is essential for the bacteria to reach the apex and cause the characteristic yellow slime symptoms.

it can then be released and inoculated during subsequent feeding events.

223. (C) I, II, III and IV
All four statements regarding Tobraviruses are correct: they are specifically transmitted by nematodes of the genus Trichodorus, they possess rigid rod-shaped particles, and they are retained on the cuticular lining of the nematode's onchiostyle and pharynx. Furthermore, like all nematode-vectored viruses, they are lost during the moulding process when the cuticular lining of the feeding apparatus is shed. This specificity reflects the highly evolved relationship between these viruses and their trichodorid vectors.

224. (A) The physical location where a virus is specifically retained within the nematode's feeding apparatus
In the context of virus transmission, functional anatomy refers to the specific physical location within the nematode's feeding apparatus where viral particles are retained. This varies between different vector-virus combinations; for example, viruses may bind to the odontophore in Xiphinema or the odontostyle in Longidorus. Identifying these retention sites is crucial for understanding how viruses are acquired, held, and eventually inoculated into host plants, and how life cycle events like moulding affect transmission.

225. (B) The cuticular lining of the feeding apparatus, where viruses are retained, is shed.
Virus infectivity is lost during nematode moulding because the viral particles are retained exclusively on the internal cuticular lining of the feeding apparatus. During each moult, the nematode entirely replaces and sheds this lining as part of its old cuticle. Since the viruses do not replicate inside the nematode or enter its internal body tissues, they are physically removed along with the shed exuviae. The nematode must feed on an infected plant again to re-acquire the virus.

226. (B) I and III
Statements I and III are correct: nematodes function as mechanical vectors by facilitating secondary bacterial infections through the creation of entry wounds and tissue maceration. Statement II is incorrect because, in mechanical vectoring, the pathogens do not typically reproduce actively inside the nematode; they simply utilize the physical damage caused by the nematode to bypass the plant's outer defenses. The relationship is based on physical facilitation rather than an obligate biological lifecycle within the vector.

227. (A) Obligate mutualism / Parasitism
An ecological interaction where one species relies entirely on another to complete its life cycle is described as obligate mutualism or parasitism, depending on whether both species benefit. For example, entomopathogenic nematodes and their symbiotic bacteria share an obligate mutualism, as neither can successfully infect and reproduce in an insect host without the other. In contrast, plant-parasitic nematodes exhibit obligate parasitism, requiring a living host plant to provide the nutrients and environment necessary for their survival and reproduction.

228. (D) Excreting excess mineral nitrogen (ammonium)
Nematodes that feed exclusively on bacteria contribute to nutrient cycling primarily by excreting excess mineral nitrogen in the form of ammonium. Because bacteria have a high nitrogen content relative to the needs of the nematodes, the surplus is voided as a metabolic byproduct. This process of nutrient mineralization increases the concentration of plant-available nitrogen in the soil, stimulating growth and productivity. These nematodes are thus essential components of healthy, nutrient-rich soil ecosystems.

229. (B) Nematode infection alters host physiology, making a normally resistant plant susceptible to a secondary pathogen.
The "breakdown of genetic resistance" occurs when nematode infection alters the host plant's physiological and structural state, allowing a secondary pathogen to overcome natural resistance mechanisms. For example, root-knot nematodes can induce metabolic changes and wounding that facilitate Fusarium wilt infection in normally resistant cultivars. The nematode's presence effectively bypasses the genetic protection that would otherwise prevent the disease, leading to severe symptoms that result from the synergistic interaction between the two pathogens.

230. (B) I, II, III, IV
The sequence of virus transmission by a vector nematode begins with feeding on an infected plant (I). During this process, viral particles are

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odontostyle. This spear is hollow and axial, allowing the nematode to penetrate deep into root tissues to feed on specialized host cells. The odontostyle and the associated odontophore provide the cuticular surfaces where Nepoviruses are retained. This structural feature is essential for their feeding behavior and their role as specific vectors for several important plant-infecting viruses.

246. (C) Rhodococcus fascians
Ditylenchus dipsaci is known to act as a mechanical vector for the bacterium Rhodococcus fascians, which together cause "cauliflower disease" in strawberries. The nematode's feeding and migration facilitate the entry and dispersal of the bacteria within the strawberry plant's tissues. The combined presence of both organisms leads to the characteristic distorted, thickened, and bushy growth symptoms that resemble a cauliflower head. This disease complex highlights how nematodes and bacteria can interact to produce unique and severe plant pathologies.

247. (B) Trichodoridae
The virus group Tobravirus is specifically vectored by nematodes in the family Trichodoridae, which includes the genera Trichodorus and Paratrichodorus. These nematodes are migratory ectoparasites that use a solid, curved feeding spear called an onchiostyle. They acquire viruses like Tobacco rattle virus while feeding on root tips and retain the rod-shaped particles on the cuticular lining of their pharynx. This highly specific relationship ensures the dispersal of these viruses to a wide range of host plants.

248. (A) The lining of the odontostyle
In Longidorus nematodes, viral particles are specifically retained on the cuticular lining of the odontostyle. This anatomical location serves as the binding site for Nepoviruses acquired from infected host plants. The specific molecular recognition between the viral coat protein and the odontostyle lining ensures that the virus remains attached as the nematode moves through the soil. During subsequent feeding on a healthy plant, the particles are released and inoculated, thereby facilitating the spread of the virus.

249. (B) Moulting
The process by which a nematode loses its ability to transmit a virus because it sheds its cuticular feeding apparatus lining is known as moulting. Viral particles are retained on these internal surfaces, and each time the nematode progresses to its next life stage, it completely replaces and sheds the old cuticle. Since the viruses are not internally persistent or replicative, they are physically removed with the exuviae, and the nematode must feed on an infected plant again to re-acquire the virus.

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250. (C) A is true but R is false.
Assertion A is true: mechanical vectors, including many soil nematodes, transmit secondary rotting microbes by providing physical entry courts through wounding and tissue damage. However, Reason R is false because these rotting microbes do not typically reproduce within the nematode's salivary glands. Instead, they simply utilize the wounds created by the nematode's feeding and migratory activities to colonize the host plant tissues, where they then multiply and cause decay.

251. (C) Antagonism / Amensalism
An interaction where one species produces a substance that is toxic to another without gaining a direct benefit is called antagonism or amensalism. In the soil rhizosphere, some microorganisms release metabolic byproducts, such as specific antibiotics or toxins, that inhibit or kill nematode populations. The producing organism does not derive any immediate metabolic advantage from the death of the nematode, making this an asymmetrical ecological relationship that significantly influences the population dynamics of soil organisms.

252. (B) They can enhance or suppress AMF colonization depending on grazing intensity.
Fungivorous nematodes interact with Arbuscular Mycorrhizal Fungi by grazing on their hyphal networks. The impact of this interaction depends on the grazing intensity; low levels of grazing can actually stimulate AMF growth by removing older hyphae and stimulating new colonization. However, high grazing intensity can severely suppress AMF networks, reducing the plant's ability to acquire nutrients. This interaction demonstrates the complex regulatory role that these nematodes play within the soil food web and its subsequent effect on plant health.

238. (A) It acts as a protective vehicle to search for and penetrate an insect host.
In the Steinernema-Xenorhabdus complex, the infective juvenile (IJ) acts as a protective mobile vehicle. Its primary role is to survive in the soil while searching for a suitable insect host. Once a host is located, the IJ penetrates the insect's body through natural orifices or the cuticle. Inside the hemocoel, it releases its symbiotic bacteria, which then kill the insect. The nematode provides the means of transport and entry, while the bacteria provide the killing power and nutrients.

239. (A) Specific attachment of parasporal fibers to receptors on the nematode cuticle
The host specificity of Pasteuria penetrans is dictated by the specific molecular attachment of the endospore's parasporal fibers to complementary receptors on the nematode's cuticle. This recognition process is highly selective, meaning that endospores will only adhere to and subsequently infect certain species or populations of nematodes. If the molecular matching is not exact, the endospore will fail to bind as the nematode moves through the soil, effectively preventing the initiation of the infection cycle.

240. (A) P-II, Q-I, R-III, S-IV
Different nematophagous fungi have specific parasitic or predatory lifestyles. Pochonia chlamydosporia is an egg parasite (P-II). Catenaria anguillulae is an endoparasite that uses motile zoospores (Q-I). Arthrobotrys oligospora captures nematodes using three-dimensional adhesive networks (R-III). Arthrobotrys dactyloides is known for its active constricting ring traps (S-IV). These varied mechanisms reflect the diverse evolutionary strategies that soil fungi have developed to exploit nematodes as a nutrient source in competitive and often nutrient-limited environments.

241. (A) Enhanced plant vigor and altered root exudation
Arbuscular Mycorrhizal Fungi confer tolerance to nematode infection primarily by improving the plant's overall health and vigor. By enhancing phosphorus acquisition and other nutrient uptake, the fungus helps the host compensate for the damage caused by nematode feeding. Additionally, AMF colonization can lead to altered root exudation patterns that may reduce nematode attraction or penetration. These physiological and biochemical changes allow the plant to maintain better growth and productivity even when under pressure from nematode populations.

242. (A) The root cortex for arbuscule and giant cell formation
Spatial competition between Glomus species and Meloidogyne occurs because both organisms require the root cortex to establish their specialized structures. AMF form arbuscules within cortical cells for nutrient exchange with the plant, while root-knot nematodes induce the development of giant cells in the same tissue region. Since there is limited space and host-derived carbon within the cortex, the presence of one can restrict the establishment and reproductive success of the other, leading to mutual suppression.

243. (C) Meloidogyne often suppresses Heterodera due to faster giant cell establishment.
During concomitant infection, a typical competitive outcome is that Meloidogyne often suppresses the population of Heterodera. This competitive advantage is frequently attributed to the root-knot nematode's ability to establish its specialized giant cell feeding sites more rapidly than the cyst nematode can form its syncytium. By securing host resources and space earlier in the colonization process, Meloidogyne can limit the available sites for Heterodera, leading to an asymmetrical reduction in the cyst nematode's reproductive success.

244. (B) Aphelenchida
Predatory nematodes of the genus Seinura belong to the Order Aphelenchida. This group is characterized by a specialized feeding apparatus that includes a hollow stylet. Seinura species use this stylet to pierce the cuticle of other soil nematodes and inject a potent paralyzing toxin. Once the prey is immobilized, the predator sucks out the internal body contents. This predatory mechanism is distinct from other groups like mononchids and highlights the diverse evolutionary paths to carnivory within the phylum Nematoda.

245. (A) An odontostyle
Virus-vectoring nematodes in the Order Dorylaimida, such as Xiphinema and Longidorus, possess a specialized feeding spear called an

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the synergistic action of Pratylenchus and Verticillium (Q-III). The bacterial wilt complex often features Meloidogyne and Ralstonia (R-I). The Fusarium wilt complex is a classic synergy between Meloidogyne and Fusarium (S-IV). These interactions demonstrate the significant role that nematodes play in predisposing crops to various bacterial and fungal diseases.

261. (A) Has a predigested insect food source free of competing opportunistic microbes
The symbiosis between Heterorhabditis and Photorhabdus ensures that the nematode has access to a pre-digested insect food source. Once the bacteria are released into the insect hemocoel, they produce toxins to kill the host and enzymes to break down its tissues. Furthermore, the bacteria secrete antibiotic compounds that inhibit the growth of competing opportunistic microbes. This maintains the insect cadaver as a specialized, nutrient-rich environment that exclusively supports the growth and reproduction of both the nematode and its bacterial partner.

262. (B) A germ tube penetrates the cuticle into the pseudocoelom.
In the life cycle of Pasteuria penetrans, immediately after an endospore attaches to the nematode cuticle, it germinates and produces a germ tube. This specialized structure penetrates directly through the thick layers of the cuticle to reach the internal pseudocoelom. Once inside this nutrient-rich cavity, the bacterium begins its vegetative growth phase, eventually consuming the nematode's reproductive system. This direct penetration is a hallmark of this obligate bacterial parasite's highly specialized infection mechanism.

263. (B) Improved host phosphorus nutrition and overall vigor
Plant tolerance to nematodes mediated by Arbuscular Mycorrhizal Fungi is often attributed to the improved phosphorus nutrition and overall vigor of the host. By establishing an extensive hyphal network, the fungus increases the surface area for nutrient absorption, helping the plant compensate for the root damage caused by nematode feeding. This enhanced metabolic status allows the host to maintain growth and yield even when infected, effectively mitigating the negative impacts of the nematode population on crop performance.

264. (B) Colonization by AMF often restricts the space available for nematode feeding site development.
When Arbuscular Mycorrhizal Fungi and endoparasitic nematodes compete for root resources, the colonization by AMF often restricts the available space for nematode feeding site development. Both organisms establish their specialized structures within the root cortex. Because there is a limited amount of cortical tissue and host-derived carbon, the presence of the fungal symbiont can lead to a reduction in the number and size of giant cells or syncytia, thereby suppressing the overall reproductive success of the nematode.

265. (C) Vascular tissue to establish distinct specialized feeding cells
During concomitant infection by root-knot and cyst nematodes, competition is primarily focused on the limited vascular tissue required to establish their specialized feeding cells. Root-knot nematodes induce giant cells, while cyst nematodes form syncytia, both of which are located within or adjacent to the vascular cylinder. As both genera vie for these high-resource sites and photosynthetically derived carbon, their populations often suffer mutual suppression, leading to niche partitioning or asymmetrical reductions in reproductive success.

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266. (A) Large, barrel-shaped stoma with one or more prominent teeth
Predatory nematodes of the genus Mononchus are easily identified by their large, heavily sclerotized, barrel-shaped stoma. This buccal cavity is typically equipped with one or more prominent teeth, which the nematode uses to grasp and puncture its prey. This robust morphology is an adaptation for an active predatory lifestyle in the soil, where mononchids feed on a variety of other small organisms, including other nematodes, playing a vital role in regulating soil community structure.

267. (B) Trichodoridae
The nematode Order Triplonchida is characterized by the presence of a solid, curved feeding spear called an onchiostyle and includes the virus-vectoring family Trichodoridae. Members of this family, such as Trichodorus and Paratrichodorus, are economically significant as they are the exclusive vectors for Tobraviruses. These nematodes live as migratory ectoparasites, feeding on root tips and transmitting viruses

between host plants. Their unique anatomy and feeding behavior distinguish them from the other group of nematode virus vectors, the dorylaimids.

268. (A) Xiphinema diversicaudatum
Xiphinema diversicaudatum is the primary nematode vector for the Arabis mosaic virus. As a member of the family Longidoridae, it acquires the virus while feeding on infected roots and retains the particles on the cuticular lining of its odontophore and esophageal bulb. This relationship is highly specific, and the dispersal of ArMV in agricultural and natural environments is closely linked to the movement and population dynamics of this particular dagger nematode species in the soil.

269. (C) Trichodorus and Paratrichodorus species
Tobraviruses, such as Tobacco rattle virus, are exclusively transmitted by nematodes in the genera Trichodorus and Paratrichodorus. These stubby-root nematodes utilize their solid, curved onchiostyle to feed on root tips, during which they acquire and transmit the viral particles. The viruses are retained on the cuticular lining of the pharynx and onchiostyle. This specific virus-vector association is a defining feature of Tobravirus epidemiology, making these nematodes critical for the spread of these pathogens in various crops.

270. (A) Both A and R are true and R is the correct explanation of A.
Both statements are true and provide a correct explanation of the virus transmission process. The retention site for Nepoviruses in Xiphinema is indeed the cuticular lining of the odontophore and esophageal bulb. Because this lining is part of the nematode's feeding apparatus, it is shed and replaced during the moulting process. This physical removal of the old cuticle results in the complete loss of viral infectivity, as the viruses do not replicate or persist internally.

271. (B) The minimum feeding time required by a viruliferous nematode to infect a healthy plant
The inoculation threshold refers to the minimum feeding time required for a viruliferous nematode to successfully infect a healthy host plant with a virus. This period represents the time needed for the nematode to penetrate the host tissues and release a sufficient quantity of bound viral particles from its feeding apparatus into the plant cells. This parameter is essential for understanding the efficiency of virus transmission and the rate of disease spread within susceptible crop populations.

272. (A) Creating wounds that serve as entry portals for secondary opportunistic pathogens
Mechanical vectoring by nematodes facilitates disease primarily by creating physical wounds that serve as entry portals for secondary opportunistic pathogens. During feeding and migration, nematodes cause significant tissue damage and maceration. Soil-borne bacteria and fungi, which may lack the specialized mechanisms to penetrate healthy roots, utilize these entry points to colonize the host. This mechanical facilitation often leads to more severe root rot and decay than would be caused by the nematodes alone.

273. (A) Indirect mutualism via nutrient cycling
The relationship between a plant and a beneficial bacterivorous nematode is described as indirect mutualism. These nematodes feed on soil bacteria, which contain higher concentrations of nitrogen than the nematodes themselves. As they digest the bacteria, they release the excess nitrogen back into the soil as ammonium. This process of nutrient mineralization increases the availability of essential elements for the plant, stimulating growth. In return, the plant provides the carbon that supports the bacterial populations.

274. (A) Formation of nutrient-rich giant cells that the fungus exploits
The formation of nutrient-rich giant cells is the most direct contributor to the breakdown of genetic resistance to Fusarium wilt in root-knot nematode infected plants. These specialized feeding sites act as high-resource metabolic sinks, accumulating sugars and amino acids that the fungal pathogen can easily exploit. The abundance of nutrients within the giant cells stimulates rapid fungal growth and invasion of the vascular system, effectively bypassing the plant's natural resistance mechanisms and leading to severe wilt.

275. (A) Disease severity greater than the sum of the individual pathogens' effects
Synergistic disease complexes involving plant-parasitic nematodes and fungi result in disease severity that is significantly greater than the sum of the individual pathogens' effects. In these interactions, one pathogen—usually

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the nematode—predisposes the host plant by creating entry wounds and inducing physiological modifications. This enhances the colonization and pathogenesis of the secondary fungal pathogen. The combined impact of both organisms leads to more rapid plant decline and higher crop losses than either could achieve independently.

276. (C) Pratylenchus penetrans
Pratylenchus penetrans is notoriously involved in a synergistic disease complex with the fungus Verticillium dahliae, particularly in potato crops. This interaction, known as "potato early dying," occurs as the migratory lesion nematodes cause extensive mechanical damage and necrosis in the root cortex. These wounds facilitate the rapid entry of the fungal pathogen into the xylem vessels. Together, they cause premature senescence and severe yield loss, making management of this complex a major challenge for potato growers.

277. (A) Adhesive networks
Arthrobotrys oligospora utilizes specialized adhesive networks to trap soil-dwelling nematodes. These three-dimensional traps are formed from hyphal loops coated with a sticky substance that ensnares nematodes on contact. This predatory behavior is an adaptive response to nutrient-limiting conditions, particularly low nitrogen. Once a nematode is trapped, the fungus penetrates the host's cuticle with infection hyphae and grows internally to consume the tissues, providing the fungus with the essential nutrients needed for growth and reproduction.

278. (B) It parasitizes eggs and sedentary females of cyst and root-knot nematodes.
Pochonia chlamydosporia is a highly effective biocontrol agent that primarily parasitizes the eggs and sedentary females of cyst and root-knot nematodes. It colonizes the rhizosphere and targets the reproductive stages of the nematodes on the root surface. By enzymatically penetrating the eggshells and the bodies of sedentary females, the fungus consumes the developing embryos and internal contents. This action significantly reduces the population of plant-parasitic nematodes by preventing the successful completion of their life cycle.

279. (A) Zoospores that encyst on body orifices
Catenaria anguillulae is an endoparasitic fungus that infects its nematode host primarily via motile zoospores. These flagellated spores move through the film of water in the soil and are attracted to the secretions from nematode body orifices, such as the mouth, excretory pore, or anus. Once they reach the host, the zoospores encyst and germinate, sending infection hyphae into the nematode's body to grow internally and consume its tissues for nutrients.

280. (A) P-I, Q-II, R-III, S-IV
Specific plant viruses are transmitted by different nematode vector genera. Tobacco rattle virus is vectored by Trichodorus (P-I). Grapevine fanleaf virus is associated with Xiphinema (Q-II). Tomato black ring virus is transmitted by Longidorus (R-III). Pea early-browning virus is vectored by Paratrichodorus (S-IV). These specific pairings are determined by the molecular recognition between the viral coat proteins and the cuticular lining of each nematode's feeding apparatus, ensuring efficient transmission within their respective host ranges.

281. (A) Provides entry courts and modifies host tissues, rendering resistant cultivars susceptible.
The synergy between Meloidogyne and Ralstonia solanacearum is highly destructive because the nematode provides entry wounds and modifies host tissues. These activities bypass the plant's natural defense mechanisms, allowing the bacterial wilt pathogen to rapidly colonize the vascular system. This interaction can render normally resistant cultivars susceptible to the disease, leading to a much higher incidence of wilting and faster plant death than would occur if either pathogen were present alone.

282. (D) Yellow ear rot (Tundu)
The physical transport of Rathayibacter tritici on the cuticle of Anguina tritici is crucial for causing yellow ear rot, also known as Tundu disease of wheat. The non-motile bacteria rely entirely on the nematode vector to be transported from the soil to the developing floral primordia of the plant. As the nematodes migrate to the wheat head, they carry the bacteria along, enabling the massive multiplication and slime production that characterize this devastating disease complex.

283. (A) A safe harbor from soil antagonists and delivery into the insect hemocoel
In the mutualistic relationship between Steinernema and Xenorhabdus, the nematode provides the bacteria with a safe harbor and

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delivery mechanism. The bacteria are carried in a specialized vesicle within the nematode's intestine, protected from soil antagonists and environmental stress. The nematode then actively searches for an insect host and penetrates its body. Once inside the hemocoel, the nematode releases the bacteria, which then multiply and produce the toxins necessary to kill the insect host.

284. (A) Requires a living nematode host to complete its life cycle and reproduce
Pasteuria penetrans is an obligate parasite, meaning it requires a living host—specifically a nematode—to complete its life cycle and reproduce. The bacterium cannot grow or multiply as a saprophyte in the soil. Its development, from endospore germination to the production of new spores, occurs entirely within the internal body cavity of the host nematode. This specialized lifestyle makes it a highly specific and effective natural regulator of many plant-parasitic nematode populations in agricultural soils.

285. (A) It decreases the damage by enhancing plant tolerance and compensating for root loss.
The presence of Arbuscular Mycorrhizal Fungi generally decreases the damage caused by plant-parasitic nematodes by enhancing host tolerance. AMF improve the plant's nutrient acquisition, particularly phosphorus, and overall vigor, which helps the host compensate for the root biomass lost to nematode feeding. Furthermore, mycorrhizal colonization can activate the plant's systemic defense pathways and alter root physiology, making the entire root system more resilient to the stresses and damage associated with nematode parasitism.

286. (B) Root cortex
Competition for spatial resources between Arbuscular Mycorrhizal Fungi and sedentary endoparasitic nematodes occurs primarily in the root cortex. This tissue layer is the site where AMF establish arbuscules for nutrient exchange and where nematodes induce the development of specialized feeding cells like giant cells or syncytia. Because both organisms require cortical space and host-derived carbon for their survival and growth, their simultaneous presence often leads to mutual suppression and intense competition for limited resources.

287. (A) They both attempt to establish their specialized feeding cells (giant cells and syncytia, respectively) in the vascular cylinder.
When Meloidogyne and Heterodera co-infect a plant, the primary cause of their interspecific competition is their shared requirement for vascular tissue. Both genera attempt to establish their specialized feeding cells within or adjacent to the vascular cylinder. Root-knot nematodes induce giant cells, while cyst nematodes form syncytia. This intense competition for space and photosynthetically derived carbon within the same root zone often results in the suppression of one species, depending on the timing of infection and host suitability.

288. (A) A hollow stylet used to inject paralyzing toxins into prey
The predatory nematode genus Seinura is defined by its use of a hollow stylet to attack prey. Unlike predators that engulf organisms, Seinura pierces the cuticle of other nematodes and injects a potent, paralyzing toxin. Once the prey is immobilized, the predator uses its stylet to suck out the internal body contents. This rapid and efficient killing mechanism allow Seinura to successfully hunt and consume a variety of soil-dwelling nematodes, including those that are much larger than itself.

289. (A) Dorylaimida and Triplonchida
The nematode families Longidoridae and Trichodoridae belong to the Orders Dorylaimida and Triplonchida, respectively. These orders are distinguished by their fundamental anatomical features, especially the structure of their feeding spears. Dorylaimid nematodes, like Xiphinema, possess a hollow odontostyle, whereas triplonchid nematodes, such as Trichodorus, have a solid onchiostyle. These taxonomic differences reflect their distinct evolutionary histories and their specific roles as vectors for different groups of plant viruses, namely Nepoviruses and Tobraviruses.

NODIA

290. (C) A is true but R is false.
Assertion A is true: Trichodorus and Paratrichodorus are the specific vectors for Tobraviruses. However, Reason R is false because these nematodes do not belong to the family Longidoridae; they are members of the family Trichodoridae. While both families contain virus-vectoring species, they are taxonomically distinct and transmit different types of viruses.

Trichodoridae vectors are characterized by their onchiostyle and are the exclusive vectors for rod-shaped Tobraviruses like Tobacco rattle virus.

291. (A) Pea early-browning virus
Pea early-browning virus is a well-known Tobravirus that is transmitted by nematodes in the family Trichodoridae. Like other Tobraviruses, it has rod-shaped particles and a bipartite genome. The virus is acquired by stubby-root nematodes, such as those in the genus Paratrichodorus, and is retained on the cuticular lining of their pharynx. This virus can cause significant economic damage in pea crops and other legumes, and its spread is entirely dependent on the presence of its specific nematode vectors.

292. (B) Paralongidorus
The nematode genus Paralongidorus, within the Order Dorylaimida, is a recognized vector for the Artichoke yellow ringspot virus. Like its relatives Xiphinema and Longidorus, Paralongidorus species possess a long odontostyle used for deep root feeding. They acquire viral particles from infected hosts and retain them on the cuticular lining of their feeding apparatus. This specific virus-vector relationship highlights the diversity of dorylaimid nematodes involved in the transmission of important plant viruses in various agricultural systems.

293. (A) The viruses are retained on the cuticular linings of the feeding apparatus, which are shed.
The loss of infectivity in virus-vectoring nematodes during moulting confirms that the viruses are retained on the cuticular linings of the feeding apparatus. Each time a nematode progresses to its next life stage, it completely replaces and sheds the old cuticle, including the internal linings where viral particles are bound. Since these viruses are not internally persistent or replicative, they are physically removed along with the shed exuviae, and the nematode must re-acquire the virus in its new stage.

294. (A) The physical tissue damage and wounding provide entry points that the microbes could not create themselves.
Mechanical vectoring by nematodes exacerbates disease because the physical tissue damage and wounding provide entry points for opportunistic microbes. Soil-borne bacteria and fungi, which often lack the specialized mechanisms to penetrate healthy root surfaces, exploit these wounds to colonize the host. This facilitation allows pathogens that would otherwise be harmless to cause severe decay and rot. The combined activity of the nematodes and these secondary microbes results in much more extensive damage than the nematodes alone.

295. (A) Steinernema and Xenorhabdus
The relationship between Steinernema nematodes and Xenorhabdus bacteria is a classic example of an obligate mutualistic symbiosis. The nematode acts as a mobile vehicle that carries the bacteria into an insect host, while the bacteria provide the toxins to kill the insect and enzymes to digest its tissues. Neither organism can successfully complete its life cycle in an insect without the other. This highly specialized partnership is the basis for their effectiveness as biological control agents against many insect pests.

296. (A) Accelerating nutrient mineralization and cycling by grazing on bacteria
The primary contribution of bacterivorous nematodes to the soil ecosystem is the acceleration of nutrient mineralization and cycling. By grazing on soil bacteria, these nematodes release excess nitrogen back into the environment as ammonium. This occurs because bacteria have a high nitrogen content relative to the metabolic needs of the nematodes. This process converts organic nutrients into inorganic forms that can be easily absorbed by plant roots, thereby stimulating overall soil productivity and supporting the growth of diverse plant communities.

297. (A) Secondary soil-borne vascular wilt fungi (e.g., Fusarium)
Nematode-induced predisposition is most critical in breaking down plant resistance to secondary soil-borne vascular wilt fungi, such as Fusarium. Nematode infection causes mechanical wounding and physiological changes that suppress the plant's natural defense responses. This allows the fungus to overcome host resistance and rapidly colonize the xylem. These synergistic interactions are common in many important crops and can lead to severe wilting and crop failure, even in cultivars that are genetically designed to resist the fungal pathogen alone.

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2024

9. Consider the following statements regarding measurement scales:
I. Yield per hectare is a ratio variable.
II. Number of seeds per pod is a continuous variable.
III. Soil pH is an interval variable.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II
(D) III

2017

10. Which scale of measurement is least informative mathematically?
(A) Nominal
(B) Ordinal
(C) Interval
(D) Ratio

2004

11. Which of the following does NOT represent an ordinal variable?
(A) Visual scoring of lodging using a scale from 1 to 5.
(B) Classifying soils by texture as sandy, loamy, or clay.
(C) Grading harvested apple quality as A, B, or C categories.
(D) Standard ranking of plant vigor based on growth rates.

2017

12. What is the effect of using a ratio scale over an interval scale in data analysis?
(A) It restricts the application of various parametric statistics.
(B) It enables calculation of coefficients of variation.
(C) It prevents the standard calculation of standard deviations.
(D) It removes the statistical ability to calculate a grand mean.

2012

13. Based on the properties of measurement scales, infer which scale must be used to meaningfully claim that one treatment yielded exactly twice as much as another.
(A) Ratio
(B) Nominal
(C) Ordinal
(D) Interval

2016

14. What graphical representation is strictly used for depicting the frequency distribution of a continuous variable?
(A) Bar chart
(B) Pie chart
(C) Histogram
(D) Scatter plot

2009

15. A frequency polygon is constructed by connecting which specific points of a histogram?
(A) The top left corners of the rectangles
(B) The top right corners of the rectangles
(C) The midpoints of the bases of the rectangles
(D) The midpoints of the top of the rectangles

2007

16. Which statement concerning cumulative ogives is accurate?
(A) They are plotted using simple frequencies instead of cumulative ones.
(B) The less-than ogive strictly decreases whenever the variable increases.
(C) Their intersection point estimates the distribution's median.
(D) They are utilized primarily to identify the mode of a distribution.

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2001

17. Why is a bar diagram inappropriate for displaying the frequency distribution of plant heights?
(A) Plant height is a discrete variable that strictly requires a histogram.
(B) It implies distinct categories unsuitable for continuous height data.
(C) Bar diagrams are limited to displaying percentages, not raw frequencies.
(D) Bar diagrams cannot handle variables possessing a true absolute zero.

2024

18. In a frequency distribution of agricultural plot yields, what determines the width of the class intervals in a histogram?
(A) The specific total count of all discrete categories.
(B) The comprehensive measurement of total area under the curve.
(C) The calculated arithmetic mean of the provided raw dataset.
(D) The data range divided by the number of classes.

CHAPTER 09
Statistics

2007

1. Which of the following defines a scale of measurement that possesses an absolute zero point?
(A) Nominal
(B) Ratio
(C) Ordinal
(D) Interval

2025

2. The number of tillers per wheat plant is classified as which type of variable?
(A) Continuous
(B) Categorical
(C) Qualitative
(D) Discrete

2011

3. Which of the following statements regarding the interval scale is INCORRECT?
(A) It possesses a true, absolute zero indicating the absence of the trait.
(B) It allows for the quantification of the difference between values.
(C) Temperature measured in Celsius is a classic example.
(D) It does not permit meaningful calculation of ratios between two measurements.

2024

4. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Plant height is considered a continuous variable rather than a discrete variable.
Reason (R): Plant height can theoretically take any infinite number of fractional values within a given range.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

5. In the context of agricultural research, how is the severity of a leaf rust infection categorized when recorded as mild, moderate, or severe?
(A) Ordinal
(B) Nominal
(C) Interval
(D) Ratio

2021

6. Match the measurement traits in List I with their appropriate scale in List II.
List I: (Trait)
P. Genotype names
Q. Soil pH
R. Yield in kg/ha
S. Disease resistance ranks
List II: (Scale)
1. Ratio
2. Interval
3. Nominal
4. Ordinal
(A) P-3, Q-2, R-1, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-1, Q-4, R-2, S-3

2005

7. A classification based on qualitative attributes where no inherent ordering exists is characteristic of which scale?
(A) Ordinal
(B) Nominal
(C) Interval
(D) Ratio

2006

8. Which of the following correctly describes a continuous variable?
(A) It is strictly limited to taking only integer values.
(B) It acts as a synonym for qualitative or categorical data.
(C) It takes any value within a defined interval.
(D) It relies exclusively on the nominal scale of measurement.

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298. (A) The combined damage is significantly greater than the sum of the damage caused by each pathogen alone.
The interaction between Meloidogyne and Fusarium oxysporum is a synergistic disease complex because the combined damage is significantly greater than the sum of the individual pathogens' effects. The nematode predisposes the plant by creating entry wounds and inducing physiological modifications in the roots. This synergy allows the fungus to establish itself more effectively and cause more severe wilting than would occur otherwise. This interaction represents one of the most economically important and widely studied disease complexes in agricultural plant pathology.

NODIA

299. (B) Verticillium dahliae
Pratylenchus penetrans is a key component in the early dying disease complex of potato, where it interacts synergistically with the fungus Verticillium dahliae. The migratory endoparasitic feeding of the lesion nematode causes extensive root wounding and necrosis, facilitating the rapid entry and spread of the fungus within the vascular system. This combined attack leads to premature senescence, severe wilting, and significant yield reductions. Managing this complex is essential for maintaining the health and productivity of commercial potato crops.

300. (A) Constricting ring
The constricting ring is a specialized trapping mechanism characterized by a three-celled loop that rapidly inflates to capture a nematode. Found in predatory fungi like Arthrobotrys dactyloides, these rings respond to physical contact by a nematode. Upon stimulation, the cells expand inward almost instantly due to a sudden increase in turgor pressure, ensnaring the prey securely. Once trapped, the fungus penetrates the nematode's cuticle and consumes its internal contents, providing the fungus with essential nutrients.

****

2009

19. Which graphical method is most relevant for identifying the total number of observations falling below a specified threshold?
(A) Less-than cumulative frequency ogive
(B) Histogram
(C) More-than cumulative frequency ogive
(D) Frequency polygon

2010

20. By comparing a histogram and a frequency polygon, one can infer that the total area under the frequency polygon is:
(A) Exactly half the area of the histogram.
(B) Unrelated to the area of the histogram.
(C) Equal to the total area of the corresponding histogram.
(D) Double the area of the corresponding histogram.

2010

21. Which visual representation is generally preferred to compare two overlapping continuous distributions on the same axes?
(A) Frequency polygons
(B) Histograms
(C) Pie charts
(D) Bar charts

2001

22. What feature distinguishes a more-than ogive from a less-than ogive?
(A) It is plotted strictly against the upper class boundaries.
(B) It always maintains an upward slope to the right direction.
(C) It is utilized solely for representing discrete data types.
(D) It uses lower boundaries and slopes downwards.

2007

23. A researcher wants to eliminate the graphical display of continuous frequencies. Which of the following must be discarded?
(A) Bar chart
(B) Histogram
(C) Pie chart
(D) Component bar diagram

2017

24. What is a primary disadvantage of using a histogram for highly skewed data with extreme outliers?
(A) It fails to demonstrate the continuous nature of the data being analyzed.
(B) It requires strictly qualitative data points to function properly.
(C) Outliers may overextend the axis and obscure the bulk of the data.
(D) It automatically results in an incorrect calculation of the arithmetic mean.

2022

25. Which of the following is an INCORRECT statement regarding the construction of a histogram?
(A) The area of each rectangle is proportional to the class frequency.
(B) It can be constructed for unequal class intervals by adjusting rectangle heights.
(C) The X-axis represents the continuous variable's class boundaries.
(D) It features gaps between adjacent rectangles to differentiate classes.

2024

26. Which graphical tool provides the best direct read of the quartiles of a dataset?
(A) Cumulative frequency ogive
(B) Frequency polygon
(C) Histogram
(D) Stem-and-leaf display

2011

27. The arithmetic mean of a set of observations is mathematically defined as:
(A) The product of all values divided by the total number of values.
(B) The sum of all values divided by the number of observations.
(C) The middlemost value when sorted.
(D) The most frequently occurring value.

2007

28. Recall the relationship among the Arithmetic Mean (AM), Geometric Mean (GM), and Harmonic Mean (HM) for a set of unequal positive observations.
(A) $AM < GM < HM$
(B) $AM = GM = HM$
(C) $AM > GM > HM$
(D) $HM > AM > GM$

2008

29. Consider the following statements concerning means:
I. The sum of deviations of observations from their arithmetic mean is always zero.
II. The geometric mean is appropriate for averaging rates and ratios.

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III. The harmonic mean is larger than the arithmetic mean for identical values.
IV. The arithmetic mean is heavily affected by extreme values.

Which of the above statement(s) is INCORRECT?
(A) I, II and IV
(B) I and III
(C) III
(D) II, III and IV

2002

30. Which measure of central tendency is best suited for computing the average rate of bacterial growth over time?
(A) Arithmetic Mean
(B) Harmonic Mean
(C) Geometric Mean
(D) Median

2015

31. What is the fundamental cause for the arithmetic mean being pulled towards the tail of a skewed distribution?
(A) Its specific mathematical calculation excludes the median.
(B) It relies on ranked order data rather than actual measured values.
(C) It serves as an unstable and unreliable measure of central tendency.
(D) It weights extreme values heavily in its sum.

2021

32. Which of the following measures is mathematically formulated as the reciprocal of the arithmetic mean of the reciprocals of the data points?
(A) Geometric Mean
(B) Median
(C) Harmonic Mean
(D) Mode

2025

33. In comparing the calculation of central tendencies, the geometric mean is undefined if the dataset contains:
(A) Extremely large positive numbers
(B) A zero or a negative number
(C) Fractional numbers
(D) Repeating identical values

2021

34. Which of the following is the most relevant mean for calculating average speed when distances are constant but times vary?
(A) Arithmetic Mean
(B) Geometric Mean
(C) Weighted Mean
(D) Harmonic Mean

2021

35. For a given set of two distinct positive numbers, the relationship between their means is mathematically given by:
(A) $GM^2 = AM \times HM$
(B) $AM^2 = GM \times HM$
(C) $HM^2 = AM \times GM$
(D) $GM = AM + HM$

2018

36. An experiment involves applying a treatment that multiplies the previous day's yield by varying factors. Which measure estimates the average daily multiplier?
(A) Arithmetic Mean
(B) Harmonic Mean
(C) Geometric Mean
(D) Median

2008

37. Which statement accurately describes a property of the arithmetic mean?
(A) It minimizes the sum of squared deviations.
(B) It minimizes the sum of absolute deviations.
(C) It is completely unaffected by outliers.
(D) It is only applicable to ordinal data.

2016

38. If the AM of two numbers is 10 and their GM is 8, infer the HM of these two numbers.
(A) 6.4
(B) 8.0
(C) 10.0
(D) 12.5

2004

39. An advantage of the arithmetic mean over the geometric mean is that:
(A) It is considerably less sensitive to the influence of extreme values.
(B) It is easier to calculate and algebraically tractable.
(C) It represents various average rates of change with higher accuracy.
(D) It always exactly equals one of the original values in the dataset.

2007

40. Which positional measure divides a ranked dataset into ten equal parts?
(A) Quartiles
(B) Percentiles
(C) Deciles
(D) Quintiles

NODIA

2023

41. The median of a distribution corresponds exactly to which of the following?
(A) The 1st quartile
(B) The 3rd decile
(C) The 75th percentile
(D) The 50th percentile

2008

42. Identify the correct statement regarding positional measures of central tendency.
(A) The median minimizes the sum of absolute deviations from itself.
(B) The mode is always located exactly midway between the mean and median.
(C) Positional measures are heavily distorted by extreme values at the tails of the data.
(D) The third quartile represents the value below which 25 percent of the observations lie.

2025

43. In a moderately asymmetrical distribution, the empirical relationship between mean, median, and mode is given by:
(A) $\text{Mean} - \text{Mode} = 3\,(\text{Mean} - \text{Median})$
(B) $\text{Mode} = 2\,\text{Median} - 3\,\text{Mean}$
(C) $\text{Median} = \dfrac{\text{Mean} + \text{Mode}}{2}$
(D) $\text{Mean} - \text{Median} = 3\,(\text{Mean} - \text{Mode})$

2007

44. What is the cause of the median being preferred over the mean in reporting agricultural landholding sizes in a heavily skewed population?
(A) The median is easier to compute than the arithmetic mean.
(B) It is robust against the influence of extreme outliers.
(C) The median utilizes every single data value in its formal mathematical calculation.
(D) The median allows for direct algebraic manipulation of the total land areas.

2024

45. Which of the following measures can be graphically determined using a histogram?
(A) Mode
(B) Arithmetic Mean
(C) Median
(D) Geometric Mean

2012

46. If the 25th percentile of grain yields is 2 tons/ha, this implies that:
(A) 75 percent of the plots yielded exactly 2 tons/ha.
(B) Average yield of the lowest 25 percent is 2 tons/ha.
(C) 25 percent of the plots yielded 2 tons/ha or less.
(D) 25 percent of the plots yielded 2 tons/ha or more.

2012

47. Which of the following positional measures is considered a measure of central tendency?
(A) The 10th percentile
(B) The 9th decile
(C) The 3rd quartile
(D) The 2nd quartile

2023

48. In a perfectly symmetrical, bell-shaped agricultural dataset, what can be inferred about its central measures?
(A) Mean $>$ Median $>$ Mode
(B) Mean $<$ Median $<$ Mode
(C) Mean $=$ Median $=$ Mode
(D) Mode $= 3\,\text{Median} - 2\,\text{Mean}$ only

2010

49. Consider the following statements concerning positional measures:
I. The median is the 5th decile.
II. The 3rd quartile equals the 75th percentile.
III. The mode is always the exact mathematical average of the quartiles.
IV. Percentiles divide the data into 100 equal parts.
V. The median is highly influenced by extreme outliers.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II, III and IV
(C) I, III and V
(D) II, IV and V

2009

50. Which measure is most relevant for identifying the most common phenotypic color appearing in a segregating plant generation?
(A) Arithmetic Mean
(B) Median
(C) Harmonic Mean
(D) Mode

2009

51. The interquartile range relies on which positional measures?
(A) 1st and 3rd quartiles
(B) 1st and 3rd deciles
(C) 10th and 90th percentiles

NODIA

(B) Coefficient of Variation
(C) Standard Error of the Mean
(D) Standard Deviation

2010

73. If the standard deviation of a plot yield is 15 kg and the sample size is 25, the standard error of the mean is:
(A) 0.6 kg
(B) 1.5 kg
(C) 3 kg
(D) 15 kg

2014

74. In a scientific publication, error bars on a bar chart representing means typically denote standard error rather than standard deviation. What is the cause of this practice?
(A) SEM represents the statistical uncertainty in estimating the mean.
(B) Standard error visually minimizes the apparent variability in the raw data.
(C) Standard error is considered significantly easier to calculate.
(D) Standard deviation cannot be calculated for replicated means.

2002

75. Through elimination, determine which of the following is NOT an application of the Standard Error of the Mean.
(A) Constructing confidence intervals for a population mean
(B) Describing the raw biological variability of individual plants
(C) Performing a Student's t-test
(D) Comparing the precision of two different sampling methods

2022

76. In comparison to SEM, the Standard Deviation is practically advantageous when the researcher's goal is to:
(A) Show the precision of the estimated population average.
(B) Show the natural spread or variation of the trait within the population.
(C) Determine whether two sample means are significantly different.
(D) Calculate test statistics for ANOVA.

2019

77. Which value is expected to change the least if the sample size is dramatically increased from 30 to 300 in a well-mixed population?
(A) Standard deviation of the sample
(B) Sum of squares
(C) Standard error of the mean
(D) Variance of the sample mean

2007

78. Based on the mathematical formulation, infer the ratio of the variance of the sample mean to the population variance.
(A) n
(B) $\sqrt{n}$
(C) $\frac{1}{n}$
(D) $\frac{1}{\sqrt{n}}$

2018

79. Skewness is a measure of a distribution's:
(A) Peakedness
(B) Central location
(C) Spread
(D) Lack of symmetry

2002

80. Select the correct order of the measures of central tendency in a continuous distribution that is strictly positively skewed.
(A) Mean $>$ Median $>$ Mode
(B) Mean $<$ Median $<$ Mode
(C) Mode $>$ Mean $>$ Median
(D) Median $>$ Mean $>$ Mode

2019

81. Kurtosis specifically describes which geometric property of a frequency distribution curve?
(A) The length of its right tail
(B) Its peakedness or flatness relative to a normal distribution
(C) Its deviation from the arithmetic mean
(D) The spread of the interquartile range

2012

82. Which of the following statements about a leptokurtic distribution is correct?
(A) It is flatter than a normal distribution.
(B) It has a kurtosis measure that is strictly less than zero.
(C) It perfectly matches the shape of a standard normal curve.
(D) It has heavier tails and a sharper peak than normal.

2007

83. The third central moment (μ_3) is fundamentally utilized to calculate the coefficient of:
(A) Skewness

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(B) Quartile deviation
(C) Median absolute deviation
(D) Range

2021

64. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The standard deviation is widely preferred over variance in practical reporting of agricultural field data.
Reason (R): The standard deviation is expressed in the same physical units as the original measured traits.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

65. If every observation in a dataset is multiplied by 2, what happens to the standard deviation?
(A) It remains unchanged.
(B) It is multiplied by 2.
(C) It is multiplied by 4.
(D) It is squared.

2017

66. Match the statistical terms in List I with their proper interpretations in List II.
List I: (Term)
P. Standard Deviation
Q. Standard Error of the Mean
R. Variance
S. Coefficient of Variation
List II: (Interpretation)
1. Dispersion of sample means around the population mean
2. Squared measure of spread from the mean
3. Relative consistency metric
4. Average distance of individual observations from the mean
(A) P-4, Q-1, R-2, S-3
(B) P-2, Q-4, R-1, S-3
(C) P-1, Q-4, R-2, S-3
(D) P-4, Q-3, R-2, S-1

2002

67. The Standard Error of the Mean (SEM) is defined as:
(A) The standard deviation of the sampling distribution of the sample mean.
(B) The standard deviation of the individual sample observations.
(C) The variance of the population divided by the sample size.
(D) The average error made during data collection.

2022

68. Which formula correctly calculates the Standard Error of the Mean?
(A) $\frac{s}{n}$
(B) $\frac{s^2}{n}$
(C) $\frac{s}{\sqrt{n}}$
(D) $s \times \sqrt{n}$

2013

69. Which of the following states the primary conceptual difference between Standard Deviation (SD) and Standard Error of the Mean (SEM)?
(A) SD describes individual spread; SEM describes mean precision.
(B) SD measures data precision, whereas SEM measures data accuracy.
(C) SD is used for continuous variables, whereas SEM is used for categorical variables.
(D) SD decreases as sample size increases, whereas SEM remains constant.

2007

70. Identify the INCORRECT statement regarding the Standard Error of the Mean.
(A) SEM is always smaller than the sample standard deviation for $n > 1$.
(B) SEM decreases as the sample size increases.
(C) SEM is essential for calculating confidence intervals for the population mean.
(D) SEM is a measure of dispersion of the underlying raw data.

2008

71. As the number of replicates in an agricultural experiment increases, what is the effect on the Standard Error of the treatment mean?
(A) It increases proportionally.
(B) It decreases.
(C) It remains constant.
(D) It fluctuates randomly.

NODIA

2019

72. Which statistic is most relevant for assessing how reliably a calculated sample mean represents the true population mean?
(A) Range

(C) np

(D) $\frac{n}{p}$

2023

95. Identify the INCORRECT statement regarding the variance of a Binomial distribution.
(A) The variance is calculated as npq.
(B) The variance reaches its maximum for a given n when $p = 0.5$.
(C) The variance is always strictly less than the mean value.
(D) Binomial variance is strictly greater than the mean.

2001

96. If 10 seeds are sown and the probability of germination for each seed is 0.8, what is the expected mean number of germinated seeds?
(A) 0.8
(B) 1.6
(C) 8.0
(D) 10.0

2017

97. In a Binomial distribution where $n = 20$ and $p = 0.5$, what is the variance?
(A) 5
(B) 10
(C) 15
(D) 20

2005

98. Which of the following is a strict requirement for a random variable to follow a Binomial distribution?
(A) The trials must be dependent on one another.
(B) The probability of success must change from trial to trial.
(C) The variable must be continuous.
(D) Each trial has exactly two mutually exclusive outcomes.

2005

99. The shape of a Binomial distribution is perfectly symmetrical under which specific condition?
(A) When $p = 0.5$, regardless of n
(B) When n is large, regardless of p
(C) When $p = 0.1$ and $n = 100$
(D) When the variance equals the mean

2014

100. Consider the following steps to calculate binomial probabilities:
I. Determine the number of trials (n) and successes (x).
II. Multiply by p^x and $(1-p)^{\{n-x\}}$.
III. Identify the probability of a single success (p).
IV. Calculate the combinations ${}^{n}C_{x}$.
Which of the following represents the correct sequence?
(A) III, I, IV, II
(B) I, III, IV, II
(C) IV, III, I, II
(D) I, II, III, IV

2023

101. An agricultural researcher evaluates 5 independent fields for the presence or absence of a specific pathogen. What distribution best models the number of infected fields?
(A) Binomial distribution
(B) Normal distribution
(C) Poisson distribution
(D) Chi-square distribution

2019

102. What is the fundamental cause of the variance being smaller than the mean in a Binomial distribution?
(A) Because p is always greater than q.
(B) Because the sample size n is finite.
(C) Because the data is discrete rather than continuous.
(D) Multiplying the mean (np) by $q < 1$ reduces the value.

2009

103. Which is the most appropriate application of the Binomial distribution in plant breeding?
(A) Modeling the exact yield of wheat in kilograms per hectare.
(B) Calculating the probability of 3 dwarfs in 10 progeny.
(C) Modeling the number of days to flowering.
(D) Comparing the mean yields of five different fertilizer treatments.

2004

104. Infer the probability of failure (q) if a Binomial distribution has a mean of 4 and a variance of 2.4.
(A) 0.4
(B) 0.5
(C) 0.6
(D) 0.2

2001

105. The Poisson distribution is fundamentally characterized as a probability model for:

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(B) Variation
(C) Kurtosis
(D) Dispersion

2006

84. If the coefficient of skewness for a dataset of plant heights is exactly zero, what can be inferred about the distribution?
(A) It is heavily weighted toward taller plants.
(B) The mean is much larger than the median.
(C) It is perfectly symmetrical.
(D) The distribution is platykurtic.

2025

85. What causes a dataset of insect counts per leaf to typically exhibit positive skewness?
(A) Most leaves have few insects, while a few have extremely high counts.
(B) Most leaves have an average number of insects, with equal deviations on both sides.
(C) The count is bounded at a high maximum limit but not at zero.
(D) Insect counts inherently follow a negatively skewed pattern.

2010

86. Which measure is most relevant for confirming that an empirical yield distribution conforms to the "bell shape" of the normal distribution in terms of tail weight?
(A) Pearson's correlation
(B) Variance
(C) Standard Error
(D) Kurtosis

2017

87. Karl Pearson's coefficient of skewness is mathematically formulated as:
(A) $\frac{\text{Mean} - \text{Mode}}{\text{Standard Deviation}}$
(B) $\frac{3\,(\text{Mean} - \text{Mode})}{\text{Variance}}$
(C) $\frac{\text{Median} - \text{Mean}}{\text{Standard Deviation}}$
(D) $\frac{\text{Mean} - \text{Median}}{\text{Variance}}$

2009

88. A distribution that is flatter than the normal distribution is formally classified as:
(A) Mesokurtic
(B) Leptokurtic
(C) Platykurtic
(D) Positively skewed

2012

89. In agricultural statistics, excess kurtosis is calculated as the standardized fourth central moment minus:
(A) 0
(B) 1
(C) 2
(D) 3

2015

90. Which combination of central tendency measures indicates a negatively skewed empirical distribution?
(A) Mean = Median = Mode
(B) Mean < Median < Mode
(C) Mean > Median > Mode
(D) Mode < Mean < Median

NODIA

2021

91. The primary advantage of identifying severe skewness in a dataset prior to conducting an ANOVA is that:
(A) It guarantees significant treatment differences.
(B) It warns against potential violations of normality assumptions.
(C) It allows the researcher to discard standard deviation.
(D) It directly improves the precision of the standard error.

2010

92. The Binomial distribution is fundamentally applied to model the probability of:
(A) A continuous variable taking a specific value.
(B) A specific success count in a fixed number of independent trials.
(C) Rare events occurring in a continuous continuum of time.
(D) The variance of a completely randomized design.

2021

93. What are the two parameters that completely define a Binomial distribution?
(A) Probability of success (p) and sample size (n)
(B) Mean and variance
(C) Degrees of freedom and p
(D) Number of successes (x) and variance

2019

94. For a Binomial distribution, the theoretical arithmetic mean is mathematically defined as:
(A) $np(1-p)$
(B) $\sqrt{npq}$

(D) Spearman's correlation formula uses the squared differences of ranks.

2010

136. What is the fundamental cause of obtaining a spurious or nonsense correlation in a dataset?
(A) A mathematical error in calculating covariance.
(B) The lack of any linear relationship between variables.
(C) A lurking third variable influences both measured traits.
(D) Using non-parametric rank tests on continuous data.

2005

137. Which term classifies a relationship where an increase in applied fertilizer is consistently associated with a decrease in soil pH?
(A) Perfect positive correlation
(B) Partial correlation
(C) Multiple correlation
(D) Negative linear correlation

2023

138. If the covariance between two traits is strictly zero, what is the value of Pearson's correlation coefficient?
(A) 0
(B) +1
(C) -1
(D) Undefined

2014

139. In comparing correlation to regression, which of the following is true?
(A) Correlation separates variables into independent and dependent; regression does not.
(B) Correlation indicates association strength; regression provides a predictive equation.
(C) Regression slopes are unitless; correlation coefficients have units.
(D) Both must mathematically result in identical numerical values.

2009

140. Which coefficient represents the strongest degree of linear relationship?
(A) +0.75
(B) -0.90
(C) +0.88
(D) -0.10

2005

141. The significance of Pearson's correlation coefficient r from a sample of size n is typically tested using which statistic?
(A) t-test with $n-2$ degrees of freedom
(B) Z-test
(C) Chi-square test
(D) F-test

2013

142. By eliminating the incorrect options, determine the coefficient of determination if the simple correlation coefficient $r = 0.8$.
(A) 0.8
(B) 1.6
(C) 0.64
(D) 0.2

2011

143. Based on the formula for Pearson's r, infer what happens if X and Y are identical variables.
(A) r will be undefined.
(B) r will be exactly 0.
(C) The covariance will be 0.
(D) r will be exactly 1.

2012

144. Partial correlation is fundamentally designed to measure the association between two variables while:
(A) Including the total variation of all other variables.
(B) Maximizing the regression coefficient.
(C) Removing the linear effect of other variables.
(D) Transforming ordinal data into continuous data.

2002

145. Multiple correlation, denoted as $R_{\{1.23\}}$, represents the correlation between:
(A) Three independent variables, excluding the dependent variable.
(B) A dependent variable and the combined linear effect of two or more independent variables.
(C) The residual errors of multiple ANOVA models.
(D) Two independent variables holding a third constant.

2019

146. For three interacting variables X_1, X_2, and X_3, what are the degrees of freedom utilized to test the significance of a first-order partial correlation coefficient $r_{\{12.3\}}$ based on a sample size n?
(A) $n-1$

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(A) Continuous data measured over time.
(B) The number of independent successes in a known, finite number of trials.
(C) The proportion of variance explained by a regression model.
(D) Rare events occurring randomly in a fixed time/space interval.

2004

106. What is the single parameter that completely define a Poisson distribution?
(A) Mean rate of occurrence (λ or m)
(B) Probability of success (p)
(C) Standard deviation (σ)
(D) Degrees of freedom

2021

107. Which unique mathematical relationship holds true for a Poisson distribution?
(A) Mean $>$ Variance
(B) Mean $<$ Variance
(C) Mean = Variance
(D) Mean = Standard Deviation

2012

108. The Poisson distribution is derived as a limiting case of the Binomial distribution under which specific conditions?
(A) $n \to \infty$ and $p \to \infty$
(B) $n \to \infty$ and $p \to 0$, such that np is constant
(C) $n \to 0$ and $p \to 0$
(D) $n \to 0$ and $p \to 1$

2024

109. Consider the following statements concerning the Poisson distribution:
I. It is an appropriate model for the number of mutations per DNA strand.
II. Its variance is larger than its mean.
III. It is a continuous probability distribution.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I
(C) II and III
(D) I and III

2002

110. Which agricultural scenario is best modeled using a Poisson distribution?
(A) Measuring the exact height of maize plants in a field
(B) Determining the sex ratio of newborn calves in a herd
(C) Counting the number of weed seeds found in a 1 kg sample of crop seed
(D) Calculating the proportion of moisture in a soil sample

2023

111. If the average number of bacterial colonies on a petri dish is 4, what is the variance of the number of colonies?
(A) 2
(B) 8
(C) 16
(D) 4

2010

112. An advantage of recognizing that count data (like insects per leaf) follow a Poisson distribution is that:
(A) It confirms the data is perfectly normally distributed.
(B) It ensures the means of different treatments are identical.
(C) It allows for data transformation to stabilize variances.
(D) It proves the events are not independent.

2001

113. Through elimination, determine which variables would NOT be expected to follow a Poisson distribution.
(A) Number of typological errors per page in a textbook
(B) Weight of apples harvested from a single tree
(C) Number of hailstorms per year in a specific agricultural region
(D) Number of nematode cysts per 100 cc of soil

2002

114. If a Poisson random variable has a variance of 3, the expected mean is:
(A) 1.5
(B) 6
(C) 9
(D) 3

2023

115. What causes the Poisson distribution curve to become increasingly symmetrical, resembling a normal distribution?
(A) As the mean (λ) becomes sufficiently large
(B) As the mean (λ) becomes very small
(C) As the probability (p) approaches 1
(D) It is fundamentally symmetrical at all times

2024

116. In the probability mass function of the Poisson distribution $P(X = x) = \frac{e^{-\lambda}\lambda^{x}}{x!}$, the mathematical constant e is approximately:
(A) 0.577

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(B) 1.618
(C) 2.718
(D) 3.141

2022

117. Based on its properties, infer why the Poisson distribution is often referred to as the "Law of Improbable Events."
(A) Probability of success in a single trial is exceedingly small.
(B) Because it is impossible to calculate its exact probabilities.
(C) Because its mean and variance are never equal in real-world data.
(D) Because it relies on irrational numbers.

2019

118. The Normal distribution is a bell-shaped curve completely defined by which two parameters?
(A) Mean and standard error
(B) Median and mode
(C) Sample size and standard deviation
(D) Mean and variance

2001

119. A Standard Normal distribution has specific parameter values defined as:
(A) Mean = 1, Variance = 0
(B) Mean = 0, Variance = 1
(C) Mean = 0, Variance = 0
(D) Mean = 1, Variance = 1

2013

120. Which transformation formula correctly converts an original normal random variable X into a standard normal Z-score?
(A) $Z = \frac{X - \mu}{\sigma^2}$
(B) $Z = \frac{\mu - X}{\sigma}$
(C) $Z = \frac{X - \mu}{\sigma}$
(D) $Z = \frac{X - \sigma}{\mu}$

2013

121. In a perfectly Normal distribution, what percentage of the total area under the curve lies strictly between $\mu - 1\sigma$ and $\mu + 1\sigma$?
(A) Approximately 50.0%
(B) Approximately 68.3%
(C) Approximately 95.4%
(D) Approximately 99.7%

2004

122. Identify the INCORRECT statement regarding the Normal distribution.
(A) The curve touches the horizontal axis at exactly 3 standard deviations from the mean.
(B) The curve is perfectly symmetrical about the mean.
(C) The total area under the probability density curve equals 1.
(D) The mean, median, and mode are structurally identical.

2006

123. The probability limits $\mu \pm 1.96\sigma$ in a normal distribution encompass exactly what proportion of the area under the curve?
(A) 90%
(B) 95%
(C) 99%
(D) 99.7%

2005

124. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The standard normal distribution allows calculation of probabilities for any normally distributed variable regardless of its original units.
Reason (R): The Z-transformation converts any normal variable to a dimensionless scale with a mean of 0 and a standard deviation of 1.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

125. The area under the standard normal curve between $Z = 0$ and $Z = \infty$ is exactly:
(A) 0.50
(B) 1.00
(C) 0.95
(D) 0.00

2013

126. Match the standard Z-score limits in List I with their corresponding enclosed cumulative probabilities (area around the mean) in List II.
List I: (Z-score limit)
P. ± 1.00
Q. ± 1.96
R. ± 2.58

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S. ± 3.00

List II: (Cumulative Probability)

1. 99.00%
2. 99.73%
3. 68.27%
4. 95.00%

(A) P-3, Q-4, R-1, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-4, R-3, S-2

2007

127. If a continuous trait in a plant population is normally distributed, the probability of selecting an individual with a value exactly equal to the population mean is mathematically:
(A) 0.5
(B) 1.0
(C) Dependent on the standard deviation
(D) 0

2008

128. What is the fundamental cause of the tails of the theoretical normal distribution extending infinitely in both directions?
(A) Natural populations always contain infinite extreme outliers.
(B) The variance of a true normal distribution is mathematically infinite.
(C) The PDF uses an exponential function that never reaches zero.
(D) The sample size used to define the curve is infinitely large.

2025

129. Consider the following statements regarding probability distributions:
I. The Binomial is continuous.
II. The Normal is continuous.
III. The Poisson is discrete.
IV. The standard normal curve has a mean of 1.
Which of the above statement(s) is/are INCORRECT?
(A) I and IV
(B) II and III
(C) I, III and IV
(D) I, II and IV

2008

130. Infer the position of a plot yield that corresponds to a Z-score of -2.5.
(A) It is exceptionally higher than the population average.
(B) It lies 2.5 variances below the population mean.
(C) It falls within the top 1% of the distribution.
(D) It lies 2.5 standard deviations below the population mean.

2006

131. Simple correlation specifically measures which aspect of the relationship between two continuous variables?
(A) The degree and direction of linear association
(B) The non-linear association
(C) The cause-and-effect dependence
(D) The proportion of variance explained

2006

132. Pearson's product-moment correlation coefficient (r) mathematically ranges between which two limits?
(A) 0 and 1
(B) -1 and 0
(C) -1 and +1
(D) 0 and 100

2009

133. Spearman's rank correlation is primarily advantageous over Pearson's correlation when:
(A) Data contains outliers or is measured on an ordinal scale.
(B) The data is perfectly normally distributed.
(C) The relationship is linear and continuous.
(D) There are more than two variables interacting.

2004

2006

134. Which of the following correctly describes a property of the simple correlation coefficient (r)?
(A) It is dependent on the change of origin but independent of scale.
(B) It is dependent on the change of scale but independent of origin.
(C) It carries the multiplied units of the two variables.
(D) It is independent of both change of origin and scale.

2021

135. Identify the INCORRECT statement concerning correlation.
(A) Correlation does not imply causation.
(B) A correlation coefficient of exactly 0 proves the two variables are entirely independent in every way.
(C) The correlation coefficient is the geometric mean of the two regression coefficients.

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(D) Mean and median

2002

52. Elimination of the highest and lowest 10 percent of observations in a dataset will definitely leave which measure unchanged?
(A) Arithmetic mean
(B) Range
(C) Median
(D) Variance

2013

53. Which absolute measure of dispersion represents the difference between the maximum and minimum observations?
(A) Range
(B) Variance
(C) Standard Deviation
(D) Mean Deviation

2025

54. The variance of a sample is defined mathematically as the expected value of the squared deviations from the:
(A) Median
(B) Mode
(C) Geometric Mean
(D) Arithmetic Mean

2023

55. Which of the following statements about the standard deviation is INCORRECT?
(A) It is the positive square root of the variance.
(B) It is a relative measure of dispersion.
(C) It possesses the same units as the original observations.
(D) It is sensitive to extreme values.

2019

56. What causes the sample variance formula to use $(n-1)$ in its denominator rather than n?
(A) To simplify calculations for large datasets
(B) To adjust for measurement errors in agricultural field trials
(C) To provide an unbiased estimator of the population variance
(D) To convert absolute dispersion into relative dispersion

2009

57. The Coefficient of Variation (CV) is classified as what type of measure?
(A) Absolute measure of dispersion
(B) Relative measure of central tendency
(C) Positional measure
(D) Relative measure of dispersion

2016

58. How is the Coefficient of Variation (CV) mathematically calculated?
(A) $\left(\frac{\text{Mean}}{\text{Standard Deviation}}\right) \times 100$
(B) $\left(\frac{\text{Standard Deviation}}{\text{Mean}}\right) \times 100$
(C) $\left(\frac{\text{Variance}}{\text{Mean}}\right) \times 100$
(D) $\left(\frac{\text{Range}}{\text{Median}}\right) \times 100$

2018

59. When comparing the consistency of yield between two different crops measured in different units, which metric is most appropriate?
(A) Variance
(B) Coefficient of Variation
(C) Standard Deviation
(D) Range

2007

60. A disadvantage of using the range as a measure of dispersion is that:
(A) It is extremely difficult to compute in large sets.
(B) It ignores all values except for the two extremes.
(C) It requires the data to follow a strictly normal bell-shaped curve.
(D) It is dimensionless.

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2016

61. If a constant value of 5 is added to every observation in a dataset, what is the effect on the variance?
(A) The variance remains unchanged.
(B) The variance increases by 5.
(C) The variance increases by 25.
(D) The variance is multiplied by 5.

2001

62. If the standard deviation of a sample is 10 and the mean is 50, what is the Coefficient of Variation?
(A) 5%
(B) 10%
(C) 20%
(D) 50%

2012

63. Which measure of dispersion is least relevant when the dataset contains extreme, unrepresentative outliers?
(A) Interquartile range

(B) $n-2$
(C) $n-3$
(D) $n-4$

2011

147. Identify the correct mathematical property of the multiple correlation coefficient (R).
(A) It ranges only between 0 and 1.
(B) It can take any value between -1 and +1.
(C) It always takes a value exactly equal to the sum of the simple correlations.
(D) It is fundamentally independent of sample size.

2009

148. Which statement correctly distinguishes first-order partial correlation from zero-order correlation?
(A) Zero-order controls for one variable; first-order controls for two.
(B) Zero-order is used for discrete data; first-order for continuous.
(C) First-order controls for an extra variable; zero-order is simple.
(D) First-order correlation must always be larger than zero-order correlation.

2017

149. Consider the following statements concerning partial and multiple correlation:
I. Multiple correlation coefficient R cannot be less than the highest simple correlation among the predictors.
II. First-order partial correlation controls for the effect of two variables.
III. Partial correlation helps uncover speculative relationships.
IV. The value of R^2 represents the proportion of variation explained by the joint predictors.
V. Multiple correlation can be negative.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, IV and V
(D) I, III, IV and V

2023

150. In a study involving yield (Y), rainfall (X_1), and fertilizer (X_2), what does the notation $r_{\{Y1.2\}}$ represent?
(A) The simple correlation between yield and rainfall.
(B) The multiple correlation of rainfall and fertilizer on yield.
(C) The partial correlation between rainfall and fertilizer, holding yield constant.
(D) The partial correlation between yield and rainfall, holding fertilizer constant.

2006

151. What causes the multiple correlation coefficient (R) to artificially increase as more independent variables are added to a model?
(A) Multicollinearity always perfectly cancels out errors.
(B) The fitting process uses chance sample variation to reduce error.
(C) Degrees of freedom naturally expand.
(D) Additional variables always perfectly cause the dependent variable.

2011

152. Which classification applies to a correlation coefficient calculated by keeping exactly two other variables constant?
(A) Zero-order correlation
(B) First-order partial correlation
(C) Second-order partial correlation
(D) Third-order multiple correlation

2011

153. A significant advantage of evaluating partial correlation in multivariate agricultural experiments is:
(A) It reduces the required sample size for experiments.
(B) It converts non-linear trends into perfectly linear models.
(C) It eliminates the need for ANOVA.
(D) It isolates direct trait relationships by removing confounding.

2018

2017

154. If simple correlations $r_{\{12\}} = 0.8$, $r_{\{13\}} = 0.8$, and $r_{\{23\}} = 1.0$, what happens to the partial correlation $r_{\{12.3\}}$ mathematically?
(A) It becomes zero or mathematically undefined due to collinearity.
(B) It becomes exactly 1.0
(C) It becomes exactly 0.8
(D) It becomes negative.

2005

155. Through elimination, identify the proportion of total variation in variable 1 NOT explained by variables 2 and 3.
(A) $R^2_{\{1.23\}}$
(B) $1 - R^2_{\{1.23\}}$
(C) $r_{\{12.3\}}$

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(A) 7.5
(B) 120
(C) 12
(D) 10

2018

235. The Randomized Block Design (RBD) is fundamentally characterized by introducing which core principle that CRD strictly lacks?
(A) Randomization
(B) Local Control (Blocking)
(C) Replication
(D) Analysis of Variance

2018

236. In the field layout of an RBD, blocks are strictly oriented:
(A) Parallel to the known fertility gradient.
(B) Perpendicular to the known fertility gradient.
(C) In a perfectly square arrangement.
(D) Randomly without regard to field gradients.

2004

237. The statistical linear model for an RBD mathematically incorporates an additional fixed effect specifically for:
(A) Replications or Blocks
(B) Interaction between blocks
(C) Columns
(D) Sampling error within plots

2004

238. Identify the INCORRECT restriction concerning the layout of a standard Randomized Block Design.
(A) The number of plots in a block must exactly equal the number of treatments.
(B) Every treatment must appear exactly once in each block.
(C) The number of blocks must be exactly equal to the number of treatments.
(D) Treatments are assigned randomly within each block independently.

2014

239. What is the fundamental cause of the efficiency gain in RBD over CRD?
(A) It drastically increases the total degrees of freedom.
(B) It removes the treatment effects entirely.
(C) It requires significantly fewer replications.
(D) Isolation of block variation from the error term decreases the Error Mean Square.

2018

240. In an RBD with t treatments and r blocks, the degrees of freedom for experimental error are mathematically derived as:
(A) $t(r-1)$
(B) $(t-1)(r-1)$
(C) $tr-1$
(D) $t+r-2$

2023

241. Comparing RBD and CRD, under what specific field condition is RBD strictly preferred?
(A) When the experimental material is perfectly homogeneous.
(B) When the experimental material exhibits a unidirectional, recognizable gradient of heterogeneity.
(C) When there is a two-way gradient of heterogeneity (e.g., both row and column slopes).
(D) When treatments destroy the plots.

2022

242. A significant disadvantage of RBD mathematically emerges when the number of treatments becomes very large. Why?
(A) The total degrees of freedom become too small.
(B) The randomization process fails mathematically.
(C) The block effects strictly become zero.
(D) Maintaining within-block homogeneity becomes difficult, increasing error variance.

2001

243. Through elimination, identify the source of variation that is NOT isolated in the standard ANOVA table of an RBD.
(A) Treatment × Block Inter action
(B) Block
(C) Treatment
(D) Experimental Error

2005

244. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In the standard ANOVA for RBD, the block-by-treatment interaction is not tested for significance.
Reason (R): The standard RBD has only one observation per cell, meaning the interaction effect is completely confounded with, and used as, the experimental error.

NODIA

(D) It splits the alpha risk into both tails, requiring more extreme values.

2012

167. Which action most reliably decreases both Type I and Type II error probabilities simultaneously?
(A) Changing the level of significance from 1% to 5%
(B) Increasing the sample size
(C) Using a one-tailed test instead of a two-tailed test
(D) Reducing the standard deviation to zero artificially

2018

168. If a researcher claims a new fertilizer is superior when, in reality, it offers no benefit over the standard, which error has been committed?
(A) Standard error
(B) Sampling error
(C) Type I error
(D) Type II error

2015

169. Based on hypothesis testing principles, infer the consequence of obtaining a p-value of 0.03 when the predetermined significance level is 0.05.
(A) Accept the null hypothesis.
(B) The test is inconclusive and must be repeated.
(C) Conclude that the null hypothesis is perfectly false.
(D) Reject the null as the data probability is below the threshold.

2008

170. Student's t-distribution is fundamentally appropriate for testing hypotheses about population means under which specific conditions?
(A) Small sample sizes ($n < 30$) and unknown population variance.
(B) Large sample sizes ($n > 30$) and known population variance.
(C) Comparing three or more treatment means simultaneously.
(D) Testing the equality of two population variances.

2002

171. In a one-sample t-test evaluating whether a sample mean significantly differs from a specified population mean (μ_0), the degrees of freedom are strictly given by:
(A) n
(B) $n-1$
(C) $n-2$
(D) $2n-1$

2006

172. Which t-test is specifically applied to compare the means of two completely distinct, unrelated sets of experimental plots?
(A) Paired t-test
(B) Independent two-sample t-test
(C) One-sample t-test
(D) Repeated measures t-test

2017

173. Identify the INCORRECT assumption for conducting an independent two-sample t-test.
(A) The sample sizes of the two groups must be exactly equal.
(B) The populations from which the samples are drawn are normally distributed.
(C) The two samples are independent of each other.
(D) The two population variances are assumed to be equal (homoscedasticity).

2002

174. What is the fundamental cause for using a paired t-test rather than an independent t-test?
(A) To increase the degrees of freedom artificially.
(B) The population variances are severely unequal.
(C) Observations are taken on the same subjects, creating correlation.
(D) The variables are measured on a nominal scale.

2024

175. For an independent two-sample t-test with sample sizes n_1 and n_2, the degrees of freedom for a pooled variance estimate are mathematically:
(A) $n_1 + n_2 - 1$
(B) $n_1 + n_2 - 2$
(C) $n_1 - 1$
(D) $(n_1 - 1) + (n_2 - 1) - 1$

2005

176. Which condition classifies a dataset as requiring Welch's t-test instead of the standard independent two-sample t-test?
(A) The two sample means are identical.
(B) The sample sizes are equal.
(C) The assumption of equal population variances is significantly violated.
(D) The observations are paired.

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degrees of freedom.

2009

196. The Chi-square (χ^2) statistic is fundamentally applied to analyze which type of data?
(A) Continuous measurements
(B) Survival time data
(C) Counted categorical or frequency data
(D) Ranked ordinal data

2003

197. In a Chi-square goodness of fit test, the mathematical formula involves the sum of:
(A) $\frac{(\text{Observed} - \text{Expected})}{\text{Expected}}$
(B) $\frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$
(C) $\frac{(\text{Observed} - \text{Expected})^2}{\text{Observed}}$
(D) $\frac{(\text{Expected} - \text{Observed})}{\text{Observed}^2}$

2007

198. Identify the INCORRECT condition for the valid application of a Chi-square test.
(A) The sample size should be reasonably large.
(B) No expected frequency should generally be less than 5.
(C) The categories must be mutually exclusive.
(D) The observed data must consist of percentages or ratios, not raw counts.

2014

199. What is the fundamental cause for applying Yates' continuity correction in a Chi-square test?
(A) The test relies on continuous data rather than discrete.
(B) Correcting the continuous approximation of discrete frequencies.
(C) To adjust for unequal sample sizes in an independent t-test.
(D) To allow expected frequencies to drop below 1 without consequence.

2023

200. Consider the following sequence of steps for conducting a Chi-square test of independence for a 2×2 contingency table:
I. Compute the squared differences divided by expected frequencies.
II. Formulate the null hypothesis of independence.
III. Calculate the expected frequency for each cell.
IV. Sum all cell values to obtain the χ^2 statistic.
Which of the following represents the correct sequence?
(A) II, III, I, IV
(B) III, I, IV, II
(C) II, I, III, IV
(D) I, II, IV, III

NODIA

2005

201. Which specific modification does Yates' correction strictly introduces into the χ^2 formula?
(A) It subtracts 0.5 from the expected frequency in the denominator.
(B) It divides the final statistic by degrees of freedom.
(C) It adds 1 to each observed frequency.
(D) It subtracts 0.5 from the absolute difference between observed and expected frequencies before squaring.

2004

202. The degrees of freedom for a Chi-square test of independence in an $r \times c$ contingency table are mathematically calculated as:
(A) $r + c - 1$
(B) $r \times c - 1$
(C) $(r-1)(c-1)$
(D) $(r-1) + (c-1)$

2022

203. Comparing goodness-of-fit and independence Chi-square tests, which statement is true?
(A) Goodness-of-fit assesses distribution matching for one variable; independence assesses association between two variables.
(B) Independence tests are primarily used for testing the equality of population variances.
(C) Independence tests utilize Yates' correction for any table size regardless of degrees of freedom.
(D) Both must mathematically assume equal expected frequencies in all cells to be valid.

2007

204. A significant advantage of the Chi-square test is that it:
(A) Directly tests the equality of population means.
(B) Provides a completely parameter-free approach for testing associations in qualitative data.
(C) Accurately estimates the magnitude and direction of linear correlation.
(D) Removes the need for randomized sampling.

List II: (Core Application)

1. Comparing variances or multiple means (ANOVA)
2. Comparing categorical expected vs observed frequencies
3. Comparing means of correlated samples
4. Hypothesis testing with known population variance

(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-1, Q-4, R-2, S-3
(D) P-3, Q-1, R-4, S-2

2011

187. In the fundamental framework of Analysis of Variance (ANOVA), the F-statistic is mathematically calculated as the ratio of:
(A) Error mean square to treatment mean square
(B) Treatment mean square to error mean square
(C) Total sum of squares to error sum of squares
(D) Treatment sum of squares to error sum of squares

2015

188. Identify the INCORRECT statement regarding the degrees of freedom for Snedecor's F-test comparing two sample variances.
(A) It requires only one value for degrees of freedom: $n_1 + n_2 - 2$.
(B) It requires two distinct degrees of freedom: $v_1 = n_1 - 1$ for the numerator and $v_2 = n_2 - 1$ for the denominator.
(C) The degrees of freedom are strictly the sample sizes.
(D) The denominator degrees of freedom must always be larger.

2017

189. What is the cause of using an F-test before proceeding with an independent two-sample t-test in classical statistics?
(A) To test the assumption of homoscedasticity (equal population variances).
(B) To verify the two population means are non-zero.
(C) To confirm the data is normally distributed.
(D) To ensure the sample sizes are equal.

2010

190. Which classification perfectly describes the mathematical relationship between Snedecor's F-statistic and Student's t-statistic for a two-group comparison?
(A) $F = t$
(B) $F = \sqrt{t}$
(C) $F = t^2$
(D) $F = \frac{t}{2}$

2008

191. Comparing the F-distribution to the normal distribution, the F-distribution:
(A) Can take negative values.
(B) Assumes completely symmetrical tails.
(C) Has an expected value of exactly 0.
(D) Has a shape that depends entirely on two degrees of freedom parameters.

2007

192. A significant advantage of Snedecor's F-test in ANOVA is its ability to:
(A) Identify exactly which pairs of means are significantly different.
(B) Correct for violations of normality inherently.
(C) Test multiple means together without inflating alpha risk.
(D) Operate perfectly on nominal data.

2014

193. Through elimination, determine which hypothesis is evaluated when Snedecor's F-test yields a significant result in a one-way ANOVA.
(A) All population variances are unequal.
(B) At least one population mean is significantly different from the others.
(C) All population means are identical.
(D) The grand mean is significantly different from zero.

2002

194. Based on the rules of probability, infer the minimum possible value an F-statistic can strictly attain.
(A) $-\infty$
(B) -1
(C) 1
(D) 0

2005

195. If the calculated F-ratio in an ANOVA is approximately 1.0, what does this strongly suggest?
(A) The treatment mean square is roughly equal to the error mean square, indicating no true treatment effect.
(B) The treatment effect is massive and highly significant.
(C) The null hypothesis should be immediately rejected.
(D) An error was made in the calculation of the

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(D) $r^2_{\{12.3\}}$

2008

156. Based on multivariate theory, infer the relationship between a simple correlation $r_{\{12\}}$ and the partial correlation $r_{\{12.3\}}$ if variable 3 is completely uncorrelated with both variables 1 and 2.
(A) $r_{\{12.3\}} > r_{\{12\}}$
(B) $r_{\{12.3\}} < r_{\{12\}}$
(C) $r_{\{12.3\}} = r_{\{12\}}$
(D) The partial correlation becomes 0.

2009

157. In hypothesis testing, the Null Hypothesis (H_0) fundamentally represents a statement of:
(A) No difference, no effect, or status quo.
(B) Significant difference between treatments.
(C) Experimental error exceeding treatment effect.
(D) Researcher's expected theoretical outcome.

2004

158. The Alternative Hypothesis (H_1) is specifically defined as:
(A) The hypothesis that is always accepted.
(B) The exact mathematical opposite of the calculated standard error.
(C) The hypothesis claiming there is a true effect or difference in the population.
(D) The hypothesis of zero variance.

2024

159. A Type I error in agricultural statistics occurs when the researcher:
(A) Fails to reject a false null hypothesis.
(B) Selects an incorrect experimental design.
(C) Calculates the test statistic incorrectly.
(D) Rejects a true null hypothesis.

2013

160. The probability of committing a Type I error is strictly denoted by which symbol?
(A) β
(B) $1 - \alpha$
(C) α (Level of significance)
(D) $1 - \beta$ (Power of the test)

2010

161. A Type II error occurs fundamentally when:
(A) The null hypothesis is true, but it is rejected.
(B) The alternative hypothesis is true, but the null hypothesis is not rejected.
(C) The level of significance is set too high.
(D) The test statistic exceeds the critical value by chance.

2013

162. Identify the correct statement regarding the level of significance.
(A) It is the probability of accepting a true null hypothesis.
(B) It is usually set after calculating the test statistic.
(C) Decreasing the level of significance simultaneously decreases the probability of a Type II error.
(D) It is the risk of concluding a difference exists when none does.

2022

2014

163. What is the fundamental cause of the inverse relationship between Type I (α) and Type II (β) errors for a fixed sample size?
(A) Lowering alpha risk makes it harder to detect a true difference.
(B) They are mathematically the exact inverse of each other ($\alpha = \frac{1}{\beta}$).
(C) The sample size strictly determines both errors independently.
(D) The standard error formula forces them to sum to 1.

2021

2010

164. Which statistical term refers to the probability of correctly rejecting a false null hypothesis ($1 - \beta$)?
(A) Level of confidence
(B) Degree of freedom
(C) Power of the test
(D) P-value

2007

165. In a one-tailed test comparing a new variety's yield against a standard check, the alternative hypothesis is correctly formulated as:
(A) $\mu_{new} = \mu_{check}$
(B) $\propto_{new} \neq \propto_{check}$
(C) $\mu_{new} > \mu_{check}$
(D) $\propto_{new} \leq \propto_{check}$

2012

166. Comparing hypothesis test types, what makes a two-tailed test more conservative than a one-tailed test?
(A) It uses a larger sample size requirement.
(B) It doubles the probability of a Type I error.
(C) It inherently reduces the power of the test to absolute zero.

NODIA

2016

205. Through elimination, identify the scenario that CANNOT be tested using a Chi-square statistic.
(A) Testing whether the variance of crop yield differs between two fields.
(B) Testing a 3:1 Mendelian segregation ratio in genetics.
(C) Determining if disease incidence is related to soil type (sandy vs clay).
(D) Testing the fairness of a rolled die.

2006

206. Based on Mendelian genetics, infer the degrees of freedom for a Chi-square goodness-of-fit test analyzing a dihybrid cross producing 4 phenotypic classes.
(A) 1
(B) 2
(C) 3
(D) 4

2022

207. If a calculated Chi-square value is zero, this strictly implies mathematically that:
(A) The expected frequencies are highly incorrect.
(B) A calculation error occurred, as Chi-square is always strictly positive.
(C) The variables are perfectly correlated.
(D) The observed frequencies perfectly match the expected frequencies.

2012

208. When calculating expected frequencies in a contingency table, the formula strictly relies on:
(A) $\frac{\text{Row Total} + \text{Column Total}}{\text{Grand Total}}$
(B) $\frac{\text{Row Total} \times \text{Column Total}}{\text{Grand Total}}$
(C) $\frac{\text{Grand Total}}{\text{Number of cells}}$
(D) Column Total − Row Total

2012

209. Consider the following statements defining the fundamental principles of the design of experiments:
I. Randomization ensures that every plot has an equal chance of receiving any treatment.
II. Replication provides an estimate of experimental error.
III. Local control increases the overall experimental error.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2011

210. Which core principle is fundamentally responsible for eliminating systematic bias in the assignment of treatments to experimental units?
(A) Local control
(B) Replication
(C) Blocking
(D) Randomization

2010

211. Identify the INCORRECT statement regarding the replication principle in experimental design.
(A) It allows for a valid calculation of the standard error of treatment means.
(B) It involves applying the same treatment to more than one experimental unit.
(C) It increases the precision of the estimated treatment effects.
(D) Increasing replication invariably completely eliminates experimental error.

NODIA

2019

212. What is the fundamental cause for implementing 'local control' (e.g., blocking) in an agricultural field experiment?
(A) To randomly assign treatments without restriction.
(B) To increase the number of treatments that can be tested.
(C) Creating homogeneous blocks to decrease overall error.
(D) To eliminate the need for replication.

2016

213. Which of the following classifications best applies to an experiment that utilizes randomization and replication but specifically lacks any local control?
(A) Completely Randomized Design (CRD)
(B) Randomized Block Design (RBD)
(C) Latin Square Design (LSD)
(D) Split Plot Design

2013

214. Which core principle is fundamentally responsible for eliminating systematic bias in the assignment of treatments to experimental units?
(A) Blocking
(B) Replication
(C) Local control
(D) Randomization

2023

215. A significant advantage of employing all three basic principles of experimental design is that it:
(A) Maximizes the total sum of squares.
(B) Provides unbiased, precise, and testable estimates.
(C) Requires fewer resources than an observational study.
(D) Prevents any Type I errors from occurring.

2001

216. Through elimination, determine which of the following is NOT an inherent purpose of replication.
(A) To provide an estimate of experimental error variance.
(B) To improve the precision of an experiment.
(C) To balance out systematic variations due to known fertility gradients.
(D) To broaden the scope of inference of the experiment.

2017

217. Based on R.A. Fisher's foundational theories, infer what constitutes "experimental error" in a field trial.
(A) Mistakes made by the researcher during data entry.
(B) The deliberate variation introduced by distinct agricultural treatments.
(C) The failure of plants to germinate.
(D) The innate variation among identical experimental units treated alike.

2009

218. In the layout of an experiment, local control is most effectively applied perpendicular to:
(A) The known fertility gradient or source of variation.
(B) The direction of randomization.
(C) The number of replications.
(D) The border rows.

2010

219. The number of degrees of freedom for experimental error in a Completely Randomized Design (CRD) with t treatments and r replications strictly equals:
(A) $(t-1)(r-1)$
(B) $t(r-1)$
(C) $tr-1$
(D) $t-1$

2018

220. Which term refers to the smallest division of experimental material to which a single treatment is applied?
(A) Treatment block
(B) Experimental unit or plot
(C) Replicate
(D) Sampling unit

2024

221. If randomization is skipped entirely, what is the immediate mathematical consequence on the statistical analysis?
(A) The assumption of independent, normally distributed errors is strictly violated, invalidating probability calculations.
(B) The standard error becomes artificially large.
(C) The treatments become perfectly correlated.
(D) The degrees of freedom drop to zero.

2009

222. Analysis of Variance (ANOVA) is fundamentally a statistical technique designed to partition:
(A) Total treatment means into individual plot values.
(B) Degrees of freedom into replication units.
(C) The total variation in a dataset into defined components associated with specific sources.
(D) Total correlation into simple and partial correlations.

2023

223. In a standard fixed-effects linear model for one-way ANOVA, the value of an individual observation $Y_{\{ij\}}$ is theoretically composed of:
(A) $\mathrm{Generalmean} + \mathrm{Treatmenteffect} + \mathrm{Randomerror}$
(B) $\mathrm{Treatmentmean} + \mathrm{Blockeffect}$
(C) $\mathrm{Variance} + \mathrm{S\,tan\,darddeviation} + \mathrm{Error}$
(D) $\mathrm{Generalmean} \times \mathrm{Treatmenteffect}$

2003

224. Identify the INCORRECT assumption underlying the standard Analysis of Variance.
(A) Experimental errors are independently and identically distributed.
(B) Experimental errors strictly follow a normal distribution.
(C) Treatment effects and block effects are strictly multiplicative.
(D) The variances among different treatment groups are homogeneous.

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2002

225. What causes the Mean Square (MS) to be derived by dividing the Sum of Squares (SS) by its degrees of freedom?
(A) It strictly converts squared units back into raw units.
(B) It calculates an unbiased estimate of the underlying population variance for that specific source.
(C) It artificially lowers the F-statistic to prevent false positives.
(D) It removes the general mean from the calculation.

2022

226. In an ANOVA table, the mathematical expectation of the Error Mean Square (EMS) under a fixed-effects model is strictly:
(A) $\sigma^2 +$ treatment variance
(B) σ^2 (the true error variance)
(C) 0
(D) 1

2014

227. Comparing the null hypothesis condition to the alternative in ANOVA, what happens to the expected value of the Treatment Mean Square if the null hypothesis is completely false?
(A) It becomes significantly larger than σ^2 due to the added variance component of the treatments.
(B) It becomes strictly equal to σ^2.
(C) It becomes significantly smaller than σ^2.
(D) It turns into a negative value.

2012

228. A significant advantage of generating an ANOVA table is that it:
(A) Directly computes the exact standard deviations of all samples.
(B) Proves exactly which two treatments differ without further testing.
(C) Provides a systematic and verifiable summary of variance partitioning and significance testing.
(D) Corrects for non-normal data automatically.

2016

229. Identify the INCORRECT combination of components strictly required to construct a full ANOVA table.
I. Degrees of Freedom
II. Sum of Squares
III. Mean Squares
IV. Standard Deviations
(A) I and II
(B) III
(C) IV
(D) II and IV

2002

230. Based on the partitioning of sum of squares, infer the equation that strictly holds true in a one-way ANOVA.
(A) $\text{Total SS} = \text{Treatment SS} + \text{Error SS}$
(B) $\text{Total SS} = \text{Treatment SS} - \text{Error SS}$
(C) $\text{Error SS} = \text{Total SS} + \text{Treatment SS}$
(D) $\text{Total SS} = \dfrac{\text{Treatment SS}}{\text{Error SS}}$

NODIA

2015

231. The term "Correction Factor" (CF) used in the manual calculation of sum of squares is mathematically defined as:
(A) Total sum of all observations divided by the number of observations.
(B) Square of the Grand Total divided by the total number of observations.
(C) Grand Total divided by the square root of observations.
(D) Sum of squared observations minus the mean.

2023

232. Which statistical property strictly validates the F-test in ANOVA?
(A) Treatment Sum of Squares and Error Sum of Squares must be perfectly equal.
(B) Mean Squares must strictly follow a normal distribution.
(C) The ratio of two independent chi-square variables, each divided by their degrees of freedom, follows an F-distribution.
(D) The total degrees of freedom must be an even number.

2013

233. Through elimination, determine which source of variation is NOT partitioned out of the total variance in a Completely Randomized Design (CRD).
(A) Treatment variation
(B) Experimental error variation
(C) Total variation
(D) Block variation

2009

234. If an ANOVA for 4 treatments and 5 replications (CRD) yields a Total Sum of Squares of 200 and a Treatment Sum of Squares of 80, infer the Error Mean Square.

2016

177. A significant advantage of the paired t-test in agricultural trials (e.g., adjacent half-leaves) is that it:
(A) Allows for testing equality of variances.
(B) Isolate treatment effects by removing biological variation.
(C) Doubles the effective degrees of freedom.
(D) Does not require the assumption of normality for differences.

2014

178. If the calculated t-value for a paired t-test of 10 plant pairs is 2.8, and the critical t-value at 5% for 9 df is 2.26, what is the appropriate conclusion?
(A) Fail to reject the null hypothesis, indicating no significant difference.
(B) Accept both hypotheses simultaneously.
(C) Conclude that the variances are unequal.
(D) Reject the null hypothesis, indicating a significant difference exists.

2019

179. Through elimination, determine which parameter is NOT required to compute an independent two-sample t-statistic.
(A) Population correlation coefficient
(B) Sample means
(C) Sample variances
(D) Sample sizes

2002

180. Consider the following steps for conducting an independent two-sample t-test:
I. Formulate hypotheses.
II. Calculate t-statistic.
III. Determine degrees of freedom.
IV. Compare with critical value.
Which of the following represents the correct sequence?
(A) I, II, III, IV
(B) IV, II, III, I
(C) I, III, IV, II
(D) II, I, IV, III

2007

181. Based on the t-distribution curve, infer what happens as the degrees of freedom increase towards infinity.
(A) The curve precisely approaches the standard normal distribution curve.
(B) The curve becomes completely flat.
(C) The variance of the curve approaches infinity.
(D) The tails become thicker and heavier.

2003

182. A paired t-test operates mathematically by performing a one-sample t-test on:
(A) The larger of the two datasets.
(B) The pooled variance of the two datasets.
(C) The geometric mean of the pairs.
(D) The set of differences calculated between the paired observations.

2010

183. Snedecor's F-test is fundamentally formulated to test the equality of two population:
(A) Means
(B) Variances
(C) Medians
(D) Proportions

2014

184. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In calculating the F-statistic to test the equality of two variances, the larger sample variance is strictly placed in the numerator.
Reason (R): Placing the larger variance in the numerator ensures the F-ratio is always greater than or equal to 1, simplifying comparison with standard one-tailed F-tables.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

185. The F-distribution curve is strictly characterized by being:
(A) Perfectly symmetrical with tails extending to infinity
(B) Negatively skewed and bounded between -1 and +1
(C) Defined by a single parameter for degrees of freedom
(D) Positively skewed and taking only non-negative values

2009

186. Match the statistical test in List I with its core theoretical application in List II.
List I: (Statistical Test)
P. F-test
Q. Paired t-test
R. Chi-square test
S. Z-test

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(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

245. Based on the concept of relative efficiency, if the relative efficiency of RBD over CRD is calculated to be 1.40, this strictly infers that:
(A) CRD requires 40% more replications to achieve the exact same precision as the RBD.
(B) RBD requires 40% more replications to match CRD precision.
(C) The block variance is precisely zero.
(D) The standard error is 1.40 times higher in RBD.

2001

246. Match the experimental design features in List I with their corresponding designs in List II.
List I: (Feature)
P. Homogeneous material, max error df
Q. One-way fertility gradient, blocks
R. Two-way fertility gradient, rows/cols
S. Main and sub-treatments, split precision
List II: (Design)
1. Split Plot Design
2. Latin Square Design
3. Randomized Block Design
4. Completely Randomized Design
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

2004

247. If an RBD layout evaluates 6 varieties across 4 blocks, what are the total degrees of freedom mathematically available in the ANOVA?
(A) 24
(B) 23
(C) 15
(D) 10

2016

248. The Latin Square Design (LSD) is fundamentally constructed to mathematically control variation strictly along:
(A) One distinct dimension.
(B) Three or more intersecting dimensions.
(C) Two orthogonal (perpendicular) dimensions simultaneously.
(D) Time and space independently.

NODIA

2022

249. Consider the following statements regarding the strict restrictions of the Latin Square Design:
I. The number of rows must exactly equal the number of columns.
II. The number of treatments must exactly equal the number of replications.
III. Every treatment must appear exactly once in each row and exactly once in each column.
IV. It is highly suitable for experiments with 20 or more treatments.
V. The error degrees of freedom are strictly $(t-1)(t-2)$.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) I, III and IV
(C) II, IV and V
(D) I, II and IV

2002

250. In a standard 5×5 Latin Square experiment, the degrees of freedom strictly assigned to experimental error are:
(A) 12
(B) 16
(C) 20
(D) 24

2013

251. Which mathematical component is added to the standard linear ANOVA model for a Latin Square Design compared to an RBD?
(A) Main plot error
(B) Column effect
(C) Covariate effect
(D) Sub-plot treatment

2016

252. Identify the INCORRECT practical application of the Latin Square Design in agriculture.
(A) Animal nutrition trials controlling for both lactation period and individual animal variance.
(B) Large-scale varietal trials testing 50 new wheat genotypes simultaneously.
(C) Greenhouse trials controlling for light gradients from the window and temperature gradients from the heater.
(D) Field trials situated on an uneven slope displaying both N-S and E-W fertility changes.

2007

253. What is the fundamental cause for the practical limitation of restricting LSD to intermediate numbers of treatments (e.g., 4 to 8)?
(A) Fewer than 4 treatments yield an Error Mean Square with practically zero degrees of freedom, severely reducing test power; more than 8 requires excessively large, heterogeneous fields.
(B) Mathematical formulas cannot compute sums of squares for matrices larger than 8×8.
(C) F-tables do not exist for $t > 8$.
(D) It is physically impossible to randomize larger squares.

2014

2007

254. Comparing the error degrees of freedom for $t = 4$ treatments, how many error df are generated in a CRD (4 reps), RBD (4 blocks), and LSD (4×4)?
(A) 12, 9, 4
(B) 12, 9, 6
(C) 15, 12, 9
(D) 16, 12, 6

2013

255. A significant advantage of the Latin Square Design mathematically is that it:
(A) Requires no randomization at all.
(B) Allows testing of three completely independent factors in one plot.
(C) Eliminates the need for a control treatment.
(D) Partitions two sources of error, providing higher precision than RBD.

2010

256. Through elimination, determine which source of variation strictly does NOT exist in the ANOVA of a basic Latin Square Design.
(A) Rows
(B) Columns
(C) Replications (as a separate factor from Rows/Columns)
(D) Treatments

2023

257. Based on experimental design principles, infer the layout shape required for an LSD strictly containing 6 treatments.
(A) Any rectangular shape totaling 36 plots.
(B) A strict 6×6 square grid containing 36 total plots.
(C) 6 rows and any number of columns.
(D) 6 completely independent blocks of 6 plots.

2009

258. If the Error Sum of Squares in an LSD is significantly larger than the Treatment Sum of Squares, what does this mathematically imply?
(A) The two-way blocking completely failed to capture the field's heterogeneity.
(B) The randomization was flawed.
(C) The F-ratio will be strictly negative.
(D) The treatment effect is statistically non-significant.

2007

259. When establishing an LSD, a "standard square" is fundamentally defined as one where:
(A) The first row and first column strictly follow an alphabetical or sequential order of treatments.
(B) All diagonal elements contain the same treatment.
(C) No treatments are repeated anywhere.
(D) The blocks are perfectly square in physical dimensions.

2022

260. Which statistical procedure ensures that an selected Latin Square is truly random for field application?
(A) Always strictly using the standard alphabetical square.
(B) Randomly assigning rows without changing columns.
(C) Randomly selecting a square from a set of all possible combinations, then randomly permuting all rows, and all columns independently.
(D) Simply dropping seed randomly in a grid.

2004

261. The "missing plot technique" in experimental design is fundamentally a mathematical procedure formulated to:
(A) Estimate the probable value of a lost observation to restore the mathematical balance of the design and allow standard ANOVA calculations.
(B) Create artificial data to increase statistical significance artificially.
(C) Remove the entire block where a plot was lost.
(D) Extrapolate treatment effects to unplanted fields.

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2013

262. For a Randomized Block Design (RBD), the formula strictly used to estimate a single missing observation (x) is:

(A) $\frac{rB+tT-G}{(r-1)(t-1)}$

(B) $\frac{rB+tT}{(r-1)(t-1)}$

(C) $\frac{rT+cC-G}{(r-1)(c-1)}$

(D) $\frac{B+T-G}{rt}$

2005

263. Identify the INCORRECT statement regarding the consequence of using the missing plot technique.

(A) The total degrees of freedom in the ANOVA must strictly be reduced by 1 for each missing plot estimated.

(B) The procedure perfectly recovers the exact biological value that was lost.

(C) The error degrees of freedom must strictly be reduced by 1 for each missing plot estimated.

(D) The treatment sum of squares must be mathematically adjusted to remove an upward bias.

2021

264. What is the fundamental mathematical objective underlying the derivation of missing plot formulas?

(A) To strictly maximize the treatment mean square.

(B) To equalize all block means.

(C) To strictly minimize the error sum of squares (least squares estimation).

(D) To ensure the missing value equals zero.

2016

265. In a Latin Square Design with t treatments, the formula mathematically derived to estimate a single missing plot requires knowing:

(A) Only the row total and column total of the missing plot.

(B) The treatment total, block total, and grand total.

(C) The mean of all remaining valid plots.

(D) The row total, column total, treatment total (of the missing plot's assigned treatment), and the grand total.

NODIA

2001

266. Comparing the degrees of freedom after estimating one missing plot in an RBD (4 treatments, 4 blocks): what are the adjusted Error degrees of freedom strictly?

(A) 8

(B) 9

(C) 12

(D) 15

2008

267. A significant procedural step after inserting a calculated missing plot value into the dataset is that the standard ANOVA is performed, but which component strictly requires a specific downward adjustment?

(A) Total Sum of Squares

(B) Treatment Sum of Squares

(C) Block Sum of Squares

(D) Correction Factor

2006

268. Through elimination, determine which experimental design fundamentally does NOT require a missing plot formula to handle unequal replication caused by lost data.

(A) Randomized Block Design

(B) Completely Randomized Design

(C) Split Plot Design

(D) Latin Square Design

2019

269. Based on statistical principles, infer the impact on the standard error of the difference between two treatment means if one of those treatments contains an estimated missing plot in RBD.

(A) The standard error is increased, requiring a specific adjusted mathematical formula.

(B) The standard error formula remains perfectly identical.

(C) The standard error is strictly smaller because the data is "perfected."

(D) The standard error becomes mathematically undefined.

2010

270. If an RBD experiment evaluates 5 treatments across 4 blocks, and exactly 2 plots are destroyed by a tractor, how many total degrees of freedom will strictly remain for the entire adjusted experiment?

(A) 12

(B) 17

(C) 18

(D) 19

ANSWERS

1. (B) Ratio
Measurement scales provide different levels of quantitative information about variables. The ratio scale is the most informative level because it includes a true, non-arbitrary zero point, which represents the complete absence of the measured trait. This property allows for meaningful calculation of ratios between values, such as identifying that one weight is exactly twice another measured weight.

2. (D) Discrete
Variables are categorized based on the values they can take. Discrete variables are represented by counts that cannot be divided into smaller fractional parts, typically resulting in whole integer values. In agricultural research, the number of tillers per plant is counted as a distinct whole unit, making it a classic example of a discrete rather than a continuous variable.

3. (A) It possesses a true, absolute zero indicating the absence of the trait.
Measurement scales include nominal, ordinal, interval, and ratio types. The interval scale is distinct because it lacks a true absolute zero point. While it allows for the measurement of the magnitude of differences between values, zero on an interval scale, like degrees Celsius, is arbitrary and does not indicate the total absence of the property being measured.

4. (A) Both A and R are true and R is the correct explanation of A.
Continuous variables are characterized by their ability to take any value within a specific range, including fractions and decimals. Plant height is measured on a continuous scale because it is not restricted to whole integers. Theoretically, an infinite number of values exist between any two measurements, such as centimeters and millimeters, confirming height as a continuous biological variable.

5. (A) Ordinal
Qualitative data that can be ranked or ordered represents the ordinal scale of measurement. When disease severity is recorded in categories like mild, moderate, or severe, there is a clear inherent hierarchy indicating the intensity of the infection. Unlike the nominal scale, which only names categories, the ordinal scale identifies relative positions of data points along a descriptive spectrum.

6. (A) P-3, Q-2, R-1, S-4
Statistical analysis requires identifying the correct measurement scale for different data types. Genotypes represent names without order, fitting the nominal scale. Soil pH represents interval data due to its log scale. Yield is ratio data because it has an absolute zero. Disease resistance ranks indicate relative positions, which is characteristic of the ordinal scale of measurement for agricultural traits.

7. (B) Nominal
The nominal scale is the most basic level of measurement used for qualitative classification. It categorizes data into distinct groups based on names or labels where no mathematical relationship or inherent order exists between them. Examples in agriculture include seed coat colors or names of different crop varieties, where the categories only serve to distinguish one item from another.

8. (C) It takes any value within a defined interval.
Continuous variables represent measurements that can be expressed with infinite precision. Unlike discrete variables, which only take specific isolated values or counts, continuous variables can take any real numerical value within a given range. This includes any number of decimal places, making this classification suitable for measuring traits such as grain moisture content, soil temperature, or plant biomass.

9. (B) I and III
Yield per hectare is a ratio variable because zero yield indicates a total absence of grain. Soil pH is an interval variable because the difference between pH values is consistent, but it lacks a true absolute zero point. However, the number of seeds per pod is a discrete variable, as seeds are counted as distinct whole integers rather than continuous values.

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(A) Error(a)
(B) A pooled combination of Error(a) and Error(b)
(C) Error(b)
(D) Block Mean Square

2012

281. Through elimination, determine which experimental layout is NOT conceptually appropriate for evaluating three distinct dates of sowing and four wheat varieties where sowing date spans large contiguous land strips.
(A) Strip Plot Design
(B) Split Plot Design (Sowing dates as main plots)
(C) Split Plot Design (Varieties as main plots)
(D) Completely Randomized Design

2007

282. Based on statistical efficiency, infer what happens if a researcher improperly analyzes a Split Plot experiment as a standard randomized complete block factorial design.
(A) Main effects will be overestimated; sub-plot effects will be underestimated.
(B) The ANOVA table will be perfectly identical.
(C) Both error terms will mathematically equal zero.
(D) The block sum of squares will strictly disappear.

2023

283. If Error(a) Mean Square is calculated to be strictly smaller than Error(b) Mean Square in a standard split plot trial, what does this mathematically suggest?
(A) It suggests standard expected behavior; Error(a) should always be smaller.
(B) It is irregular, as Error(b) is usually smaller due to homogeneity.
(C) It proves the main plot treatments had no effect.
(D) It proves the sub-plot treatments had no effect.

2005

284. In a Split Plot experiment with 3 main-plot factors, 4 sub-plot factors, and 3 blocks, strictly calculate the degrees of freedom for Error(b).
(A) 4
(B) 6
(C) 18
(D) 24

2004

285. Which component mathematically represents the Error(a) variation in the ANOVA of a basic Split Plot Design laid out in blocks?
(A) Replication $\times$ Main $-$ plot interaction
(B) Replication $\times$ Sub $-$ plot interaction
(C) Main $-$ plot $\times$ Sub $-$ plot interaction
(D) Sub-plot variance alone

2011

286. What is the core reason a Split Plot Design fundamentally sacrifices precision on the main-plot factor?
(A) Because main plots are never randomized.
(B) Because main plots use fewer blocks.
(C) Large main plots capture more unmeasured soil heterogeneity.
(D) Because the ANOVA strictly prevents testing the main plot effect.

2018

287. Post-ANOVA testing (such as computing the Critical Difference) is strictly initiated mathematically only if:
(A) The null hypothesis of the overall ANOVA F-test is accepted.
(B) The experimental error is calculated to be strictly zero.
(C) The treatments are entirely completely randomized.
(D) The overall ANOVA F-test for treatment effects is found to be statistically significant.

2016

288. The Critical Difference (CD), also known as the Least Significant Difference (LSD), is fundamentally formulated mathematically as:
(A) $t_{\alpha} \times$ Variance
(B) $t_{\alpha} \times \sqrt{\dfrac{2 \times \text{Error Mean Square}}{r}}$
(C) Error Mean Square $\times$ Standard Error
(D) $\dfrac{\text{Treatment Mean Square}}{\text{Error Mean Square}}$

2004

289. Identify the INCORRECT assumption in strictly applying the standard Critical Difference test to compare treatment means.
(A) It strictly requires equal replication for the basic formula to be straightforwardly applied.
(B) It can perfectly evaluate multiple completely independent continuous variables simultaneously.

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2012

271. When estimating a missing value in RBD using $x = \frac{rB + tT - G}{(r-1)(t-1)}$, what does the variable 'G' strictly represent?
(A) Grand total including the missing value.
(B) Geometric mean of the block.
(C) Total of the block missing the plot.
(D) Grand total of all available valid observations in the experiment.

2004

272. Which iterative mathematical process is strictly required if two plots are missing in a Latin Square Design?
(A) Guessing both values as zero and stopping.
(B) Using the CRD missing plot formula twice.
(C) Substituting a guessed mean for the first missing plot, calculating the second via formula, then using that to recalculate the first, repeating until values stabilize.
(D) Multiplying the two missing values together.

2009

273. The primary justification for expending effort to mathematically estimate a missing plot rather than just ignoring the entire block is:
(A) Missing plot formulas inherently fix bad randomization.
(B) Ignoring blocks wastes valid data collected from other treatments.
(C) It ensures the F-statistic will be larger.
(D) It creates a perfectly orthogonal matrix.

2011

274. The Split Plot Design is fundamentally constructed for multi-factor experiments where:
(A) All factors strictly require exactly the same size of experimental plot.
(B) Neither factor can be randomized.
(C) The field has perfectly uniform fertility.
(D) One factor physically or practically requires larger experimental units than the other factor.

2018

275. In a strict Split Plot Design layout, the levels of the main plot factor are randomized over the main plots, and then the levels of the sub-plot factor are:
(A) Randomized independently within each individual main plot.
(B) Applied systematically without randomization.
(C) Randomized over completely separate blocks.
(D) Randomized identically across all main plots simultaneously.

2013

276. Identify the correct architectural feature of the standard ANOVA for a Split Plot Design.
(A) It strictly yields a single pooled error term.
(B) It removes the block effect entirely.
(C) It strictly produces two distinct error terms: Error(a) for main plots and Error(b) for sub-plots.
(D) It fails to calculate the interaction effect between the two factors.

NODIA

2004

277. What is the fundamental cause for the precision difference between main-plot treatments and sub-plot treatments in this design?
(A) Sub-plots use a more homogeneous local environment, lowering Error(b).
(B) Main-plot treatments are replicated more times than sub-plot treatments.
(C) Sub-plot treatments are never fully randomized.
(D) The Error(a) term is mathematically constrained to zero.

2021

278. In a classic agricultural application of the Split Plot Design, which factor is most appropriately strictly assigned to the main plots due to machinery constraints?
(A) Crop variety (sown by hand)
(B) Nitrogen fertilizer top-dressing
(C) Foliar fungicide spray using backpack sprayers
(D) Irrigation scheduling (applied via massive overhead sprinklers)

2010

279. Comparing the degrees of freedom for the two error terms in a Split Plot Design (Main factor A with a levels, Sub factor B with b levels, r blocks), the degrees of freedom for Error(a) strictly correspond to the error df of which simpler design?
(A) CRD
(B) RBD with a treatments and r blocks
(C) LSD
(D) Factorial RBD with $a \times b$ treatments

2009

280. A significant statistical consequence of the Split Plot Design mathematically is that testing the significance of the Interaction Effect strictly utilizes:

(D) Exclusively for qualitative, non-numeric descriptive data.

2023

299. In reporting agricultural trial results, treatments displaying the strictly identical alphabet letter following Duncan's Multiple Range Test or CD grouping inherently indicate:

(A) They are strictly significantly different from each other.

(B) They are not strictly significantly different from each other at the specified alpha level.

(C) They are strictly mathematically exactly equal in raw value.

(D) They strictly belonged to the same exact block.

2016

300. The mathematical relationship between the standard error of a single mean (SEm) and the standard error of difference between two equal-replicated means (SED) is strictly given by:

(A) $SED = SEm$

(B) $SED = SEm \times 2$

(C) $SED = SEm \times \sqrt{2}$

(D) $SED = \frac{SEm}{\sqrt{2}}$

****

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(C) It does not adequately control the experiment-wise Type I error rate when conducting a massive number of pairwise comparisons.
(D) It strictly relies on the Error Mean Square from the ANOVA table.

2011

290. What is the fundamental cause of the Critical Difference formula strictly incorporating a multiplier of $\sqrt{2}$?
(A) To strictly halve the standard error.
(B) Variance of the difference of independent means is the sum of their variances.
(C) Because ANOVA strictly uses two tails.
(D) To adjust for using only two replications.

2021

291. In an RBD where 5 fertilizer treatments were tested across 4 blocks with an Error Mean Square of 18, strictly compute the Standard Error of Difference (SED) between two treatment means.
(A) 3
(B) 4.5
(C) 9
(D) 18

2003

292. Comparing treatment means utilizing the Critical Difference (CD), if the absolute difference between Mean A (25 kg) and Mean B (20 kg) is strictly 5 kg, and the calculated CD value is 3.5 kg, what is concluded?
(A) The two means strictly do not differ significantly.
(B) The two means differ strictly, but not significantly.
(C) The two means are statistically significantly different.
(D) The ANOVA must strictly be recalculated.

2017

293. A significant disadvantage of relying strictly on Fisher's unprotected LSD for making 20 pairs of treatment comparisons is that mathematically:
(A) Family-wise Type I error rate inflates far beyond the set alpha level.
(B) The test relies strictly on categorical data.
(C) It prevents calculating the standard error.
(D) It artificially inflates the degrees of freedom.

2004

294. Through elimination, strictly identify the post-hoc test that is NOT inherently designed to control the experiment-wise Type I error inflation encountered with simple LSD.
(A) Tukey's Honestly Significant Difference (HSD)
(B) Duncan's Multiple Range Test (DMRT)
(C) Bonferroni Correction
(D) Fisher's basic Critical Difference (without significant prior F)

NODIA

2021

295. Based on post-ANOVA principles, infer which strictly required table value is used to calculate the CD at a 5% level of significance.
(A) F-table value strictly at Error degrees of freedom
(B) t-table value strictly at Error degrees of freedom for a two-tailed test
(C) Z-table value strictly for 0.05
(D) Chi-square table value

2007

296. If the calculated Error Mean Square in a perfectly laid out agricultural trial strictly equals zero, what is the mathematical consequence for the Critical Difference?
(A) The CD mathematically equals 1.
(B) The CD approaches strictly infinity.
(C) The CD strictly equals zero, implying any minute mathematical difference between sample means is deemed "significant."
(D) The test strictly defaults to a Z-test.

2006

297. When comparing two means involving estimated missing plots in an RBD, the strictly correct calculation of the Critical Difference requires:
(A) Strictly utilizing the exact same simple formula as with complete data.
(B) Substituting the Treatment Mean Square for the Error Mean Square.
(C) Reducing the t-value multiplier strictly to 1.
(D) Inflating the SED using a specific adjustment factor for lost data.

2022

298. Which strictly states the condition under which applying the Critical Difference test is deemed mathematically appropriate by modern statisticians?
(A) Only for specifically planned pre-planned orthogonal contrasts or when the overall F-test is significant for a small number of unstructured treatments.
(B) When strictly comparing exactly 50 completely distinct treatments all at once.
(C) Whenever the overall ANOVA strictly accepts the null hypothesis.

10. (A) Nominal
Measurement scales provide varying degrees of mathematical utility. The nominal scale is considered the least informative because it only provides qualitative labels for categories. It does not allow for ranking, determining the magnitude of differences, or calculating ratios. Consequently, only a limited number of statistical operations, such as mode and frequency counts, can be performed on nominal data in research.

11. (B) Classifying soils by texture as sandy, loamy, or clay.
Ordinal variables represent categories with a logical rank or sequence. Visual scores, quality grades, and vigor ranks all imply a hierarchy from low to high. In contrast, classifying soil by names like sandy, loamy, or clay is purely nominal. These categories distinguish types based on composition without an inherent quantitative order that would classify one as numerically superior.

12. (B) It enables calculation of coefficients of variation.
The ratio scale includes an absolute zero point, which is essential for certain mathematical calculations. Unlike the interval scale, where zero is arbitrary, the ratio scale allows for the meaningful computation of proportions and coefficients. Calculating the coefficient of variation requires dividing the standard deviation by the mean, an operation that is only statistically valid when using ratio-level measurement data.

13. (A) Ratio
Determining that one value is exactly a multiple of another requires a scale with a true zero point. The ratio scale possesses this property, allowing researchers to claim that one treatment produced twice the yield of another. On scales without an absolute zero, such as the interval scale, the ratio of two measurements is mathematically meaningless and lacks physical interpretation.

14. (C) Histogram
Histograms are specifically designed to represent the frequency distribution of continuous data. They consist of adjacent rectangles where the base represents the class interval and the area corresponds to the frequency. Because continuous variables have no gaps between values, the rectangles in a histogram are drawn touching each other, visually distinguishing them from bar charts used for discrete categories.

15. (D) The midpoints of the top of the rectangles
A frequency polygon provides a visual representation of a distribution by using a line graph. It is constructed by identifying the midpoint at the top of each rectangle in a histogram, which represents the class frequency at the class mark. Connecting these midpoints with straight lines allows for a smoother visualization of the shape and trends of the dataset.

16. (C) Their intersection point estimates the distribution's median.
Cumulative frequency ogives are graphs that show the running total of frequencies across a distribution. The less-than ogive increases as it moves to the right, while the more-than ogive decreases. When both curves are plotted on the same axes, their point of intersection corresponds to the 50th percentile of the data, which is defined as the distribution's median.

17. (B) It implies distinct categories unsuitable for continuous height data.
Bar diagrams are used to display discrete categories or qualitative data, where gaps between bars indicate that the variables are distinct. Plant height is a continuous variable where values flow into one another without interruption. Using a bar diagram would incorrectly suggest that heights fall into separate, unrelated bins rather than following a continuous distribution across a numerical spectrum.

18. (D) The data range divided by the number of classes.
Constructing a histogram requires organizing raw data into class intervals. The width of these intervals is determined by identifying the range, which is the difference between the maximum and minimum observations, and dividing it by the desired number of classes. Uniform class widths ensure that the visual representation accurately reflects the density of observations across the entire measurement range.

19. (A) Less-than cumulative frequency ogive
A less-than cumulative frequency ogive is used to determine the total number of observations that fall below a specific value. It is constructed by adding the frequency of each class to the sum of all preceding classes. This graphical tool is

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particularly useful for identifying percentiles and calculating the proportion of the population that fails to meet a certain threshold.

20. (C) Equal to the total area of the corresponding histogram.
A frequency polygon is essentially a line-based abstraction of a histogram. By connecting the midpoints of the histogram bars and extending the ends to the horizontal axis, the areas added outside the bars are mathematically compensated for by the areas excluded inside. Consequently, the total area under the frequency polygon remains exactly equal to the area enclosed by the histogram.

21. (A) Frequency polygons
When researchers need to compare two or more continuous distributions on a single set of axes, frequency polygons are generally preferred over histograms. Overlapping histograms often become visually cluttered and difficult to interpret as the bars block one another. In contrast, the line-based nature of frequency polygons allows multiple distributions to be superimposed clearly, facilitating easier comparison of shapes.

22. (D) It uses lower boundaries and slopes downwards.
Cumulative frequency curves are plotted in two forms. The less-than ogive uses upper class boundaries and slopes upward, representing the accumulation of data from the bottom. The more-than ogive uses lower class boundaries and slopes downward, representing the remaining total as values increase. This downward slope identifies how many observations are equal to or greater than a specific value.

23. (B) Histogram
Graphical tools are categorized by the type of data they represent. Bar charts, pie charts, and component diagrams are typically used for discrete or categorical data points. In contrast, the histogram is the primary graphical representation strictly reserved for continuous frequency distributions. To eliminate the display of continuous frequencies, the histogram must be discarded in favor of discrete-oriented charts.

24. (C) Outliers may overextend the axis and obscure the bulk of the data.
Histograms rely on class intervals to show data density. When a dataset contains extreme outliers, the horizontal axis must be extended to include these distant points, which can compress the majority of the data into a small, unreadable area. This obscures the actual shape of the distribution, making it difficult to analyze the central tendencies and variability of the population.

25. (D) It features gaps between adjacent rectangles to differentiate classes.
A histogram is constructed to represent continuous data, where one class boundary ends exactly where the next begins. To reflect this continuity, the rectangles in a histogram must touch one another without any gaps. The presence of gaps is a characteristic feature of bar charts, which are used for discrete categories rather than continuous numerical variables like weight or height.

26. (A) Cumulative frequency ogive
Positional measures such as quartiles, deciles, and percentiles can be easily read from a cumulative frequency ogive. By identifying the specific point on the vertical frequency axis (such as 25% for the first quartile), one can project horizontally to the curve and then vertically down to the horizontal axis to find the corresponding data value in the distribution.

27. (B) The sum of all values divided by the number of observations.
The arithmetic mean is a fundamental measure of central tendency that represents the mathematical average of a dataset. It is calculated by totaling the values of all individual observations and then dividing that sum by the total count of those observations. This measure is widely used because it incorporates every data point into its final calculated value for analysis.

28. (C) $AM > GM > HM$
For any set of positive and unequal observations, a specific mathematical hierarchy exists between the three Pythagorean means. The arithmetic mean is always the largest, followed by the geometric mean, with the harmonic mean being the smallest. These three values only become equal to one another when all observations in the dataset are identical, representing a perfectly uniform population.

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29. (C) III
The properties of means are well-defined in statistics. The sum of deviations from the arithmetic mean is always zero, and the mean is sensitive to outliers. The geometric mean is indeed suitable for rates. However, for unequal positive observations, the harmonic mean is always the smallest of the three means, making the statement that it is larger than the arithmetic mean incorrect.

30. (C) Geometric Mean
The geometric mean is the most appropriate measure for calculating averages of values that change multiplicatively, such as growth rates, ratios, or percentages. In microbiology, bacterial populations grow exponentially over time. Using the arithmetic mean would result in an overestimation, whereas the geometric mean provides an accurate estimate of the central rate of increase across different time intervals.

31. (D) It weights extreme values heavily in its sum.
The arithmetic mean is highly sensitive to the presence of outliers because its calculation requires summing the actual values of every observation. In a skewed distribution, extreme values in the tail contribute disproportionately to the total sum, pulling the mean away from the center toward the tail. This makes the mean a less representative measure of typicality in heavily skewed datasets.

32. (C) Harmonic Mean
The harmonic mean is a specialized measure of central tendency used for certain types of data, such as rates and ratios. It is mathematically defined as the reciprocal of the arithmetic mean of the reciprocals of the observations. This calculation method gives more weight to smaller values in the dataset and is particularly useful when averaging speeds or rates over constant distances.

33. (B) A zero or a negative number
The geometric mean is calculated by finding the nth root of the product of all observations. If any single value in the dataset is zero, the entire product becomes zero. Similarly, negative numbers can result in complex or undefined roots. Therefore, the geometric mean is strictly defined and useful only for datasets consisting of positive, non-zero numerical values.

34. (D) Harmonic Mean
The harmonic mean is the mathematically correct average to use when dealing with rates where the numerator remains constant while the denominator varies. For example, when calculating average speed for trips of equal distance but varying times, the harmonic mean accounts for the different time durations correctly. The arithmetic mean would provide a biased result by failing to weight the times properly.

35. (A) $GM^2 = AM \times HM$
For any two positive numbers, a strict mathematical relationship exists between the arithmetic mean, geometric mean, and harmonic mean. The square of the geometric mean is equal to the product of the arithmetic and harmonic means. This indicates that the geometric mean is the geometric average of the other two means, illustrating the consistent internal logic between these measures of central tendency.

36. (C) Geometric Mean
When an experiment involves a series of multiplicative factors, such as daily growth multipliers or compound interest rates, the geometric mean is used to find the average multiplier. It represents the single constant factor that, if applied repeatedly, would result in the same final yield. The arithmetic mean is unsuitable here as it averages additive changes rather than multiplicative ones.

37. (A) It minimizes the sum of squared deviations.
The arithmetic mean possesses a unique mathematical property known as the least squares property. The sum of the squared differences between each observation and the mean is smaller than the sum of squared differences calculated from any other value. This characteristic makes the mean a critical component in many statistical procedures, including regression analysis and the calculation of variance in datasets.

38. (A) 6.4
The relationship between the three means is defined by the formula where the geometric mean squared equals the product of the arithmetic and harmonic means. Given an arithmetic mean of 10 and a geometric mean of 8, squaring 8 results in 64. Dividing 64 by the arithmetic mean of 10 yields a harmonic mean of 6.4 for those two numbers.

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39. (B) It is easier to calculate and algebraically tractable.
The arithmetic mean is widely used in research because its formula is simple and it allows for further algebraic manipulation. For example, the mean of a combined group can be calculated if the means and sizes of individual groups are known. The geometric mean is more computationally complex and lacks the same level of algebraic flexibility for combined data analysis.

40. (C) Deciles
Positional measures, also known as quantiles, divide a sorted dataset into equal parts. Quartiles divide the data into four parts, and percentiles divide it into one hundred parts. Deciles specifically divide the ranked observations into ten equal groups, with each group containing ten percent of the total data. These measures help researchers understand the distribution and spread of observations in a population.

41. (D) The 50th percentile
The median is the middle value of a dataset when the observations are arranged in order of magnitude. In terms of other positional measures, the median corresponds exactly to the 50th percentile, the 5th decile, and the 2nd quartile. All of these values signify the point below which exactly half of the observations in the distribution are located.

42. (A) The median minimizes the sum of absolute deviations from itself.
A unique mathematical property of the median is that the sum of the absolute differences between each observation and the median is at its minimum. Unlike the arithmetic mean, which minimizes squared deviations, the median focuses on absolute distance. This characteristic makes the median a robust measure of central tendency, especially when the data contains extreme values or is skewed.

43. (A) $\text{Mean} - \text{Mode} = 3(\text{Mean} - \text{Median})$
In distributions that are moderately asymmetrical, there is a predictable empirical relationship between the three measures of central tendency. This relationship states that the distance between the mean and the mode is approximately three times the distance between the mean and the median. This formula allows statisticians to estimate one value if the other two measures are known.

44. (B) It is robust against the influence of extreme outliers.
Agricultural landholdings are often heavily skewed, with many small farms and a few exceptionally large estates. The arithmetic mean is pulled upward by these large outliers, providing a misleading average. The median, however, is a positional measure that remains unaffected by the actual values of extreme outliers, offering a more representative "typical" size for the majority of the population.

45. (A) Mode
The mode represents the most frequently occurring value in a dataset. In a frequency distribution, it corresponds to the peak of the curve. Graphically, the mode can be determined using a histogram by identifying the tallest rectangle, which represents the modal class, and then using a specific interpolation method within that class to find the exact modal value.

46. (C) 25 percent of the plots yielded 2 tons/ha or less.
Percentiles indicate the relative standing of a value within a dataset. If the 25th percentile of grain yield is 2 tons per hectare, it means that 25% of all the recorded observations are equal to or lower than this value. Conversely, the remaining 75% of the observations in the dataset have yields that are greater than 2 tons per hectare.

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47. (D) The 2nd quartile
While many quantiles describe positions within a distribution, only those that identify the center are considered measures of central tendency. The 2nd quartile, like the 5th decile and the 50th percentile, is another name for the median. It represents the exact middle of the sorted data, whereas other quartiles or percentiles describe points closer to the tails of the distribution.

48. (C) $\text{Mean} = \text{Median} = \text{Mode}$
In a perfectly symmetrical distribution, such as the normal distribution, the data is balanced equally on both sides of the center. Because there is no skewness, the most frequent value (mode), the middle value (median), and the mathematical average (mean) all coincide at the same central point. This alignment is a primary characteristic of bell-shaped frequency curves in statistics.

49. (A) I, II and IV
Positional measures provide standardized ways to divide data. The median is correctly identified as the 5th decile, and the 3rd quartile is equivalent to the 75th percentile. Furthermore, percentiles divide a dataset into 100 equal parts. These statements accurately describe how quantiles function, whereas the mode is not necessarily related to quartiles, and the median is robust against outliers.

50. (D) Mode
The mode is the measure of central tendency that identifies the most frequent category or value in a dataset. In genetics, when observing phenotypic traits like color, researchers look for the category that appears most often in the offspring. Since color is a nominal categorical variable, the mode is the only appropriate measure of central tendency to describe the typical phenotype.

51. (A) 1st and 3rd quartiles
The interquartile range is a measure of dispersion that describes the spread of the middle 50 percent of a dataset. It is calculated by finding the difference between the third quartile, which marks the 75th percentile, and the first quartile, which marks the 25th percentile. This measure is useful because it excludes the extreme values found in the tails.

52. (C) Median
The median is a positional measure of central tendency that depends only on the order of values and the middle location of the dataset. Removing an equal percentage of observations from both the high and low ends of the distribution does not change the middle position. Consequently, the median remains unchanged, while measures like the mean, range, and variance are affected.

53. (A) Range
The range is the simplest absolute measure of dispersion. it is calculated by subtracting the smallest value in the dataset from the largest value. It provides a quick estimate of the total spread of the data. However, since it only considers the two extreme observations, it does not provide information about how the remaining data points are distributed within those limits.

54. (D) Arithmetic Mean
Variance is a fundamental statistical measure that quantifies the degree of spread in a dataset. It is mathematically defined as the average of the squared deviations of each observation from the arithmetic mean. By squaring the differences, variance ensures that all deviations are treated as positive values, providing an overall measure of how much the data points vary around the center.

55. (B) It is a relative measure of dispersion.
The standard deviation is the positive square root of the variance and is an absolute measure of dispersion. Because it is expressed in the same units as the original data, it is easily interpretable. Relative measures of dispersion, such as the coefficient of variation, are unitless. The standard deviation remains sensitive to extreme values, just like the variance from which it is derived.

56. (C) To provide an unbiased estimator of the population variance
When calculating variance from a sample rather than a whole population, using the sample size in the denominator tends to underestimate the true population variance. Dividing by the degrees of freedom, which is the sample size minus one, corrects this mathematical bias. This adjustment ensures that the sample variance is an accurate, unbiased estimator of the variance in the larger population.

57. (D) Relative measure of dispersion
Measures of dispersion are categorized as either absolute or relative. Absolute measures, like standard deviation, have units. Relative measures are unitless and are used to compare variability across different datasets. The coefficient of variation is a relative measure that expresses the standard deviation as a percentage of the mean, allowing for comparisons between variables with different units or scales of measurement.

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58. (B) $\left(\frac{\text{Standard Deviation}}{\text{Mean}}\right) \times 100$
The coefficient of variation is a standardized measure used to describe the consistency of data. It is calculated by dividing the standard deviation by the arithmetic mean and then multiplying the result by one hundred to express it as a percentage. This formula allows researchers to evaluate the relative variability of a trait in proportion to the magnitude of its average value.

78. (C) $\frac{1}{n}$
There is a direct mathematical relationship between the variance of a sample mean and the variance of the underlying population. The variance of the mean is calculated by dividing the population variance by the sample size. Therefore, the ratio of the variance of the mean to the population variance is equal to one divided by the number of observations in the sample.

79. (D) Lack of symmetry
Skewness is a statistical measure used to describe the asymmetry of a frequency distribution. A perfectly symmetrical distribution, such as the normal distribution, has a skewness of zero. When the data is weighted more heavily toward one tail than the other, the distribution is considered skewed. Skewness helps researchers understand whether observations are concentrated at one end of the measurement scale.

80. (A) Mean > Median > Mode
In a positively skewed distribution, the tail on the right side is longer or fatter than the left side. This skewness pulls the arithmetic mean toward the higher values in the tail. The mode remains at the peak of the distribution, and the median falls between the two. Consequently, the mean is greater than the median, which is greater than the mode.

81. (B) Its peakedness or flatness relative to a normal distribution
Kurtosis is a measure of the shape of a probability distribution, specifically focusing on the peak and the tails. It describes how "pointed" or "flat" the distribution curve appears when compared to a standard normal distribution. High kurtosis indicates a sharp peak and heavy tails, while low kurtosis signifies a flatter top and lighter tails in the data distribution.

82. (D) It has heavier tails and a sharper peak than normal.
Distributions are classified by their kurtosis values. A leptokurtic distribution is characterized by a higher, sharper peak and thicker tails than the normal distribution. This shape indicates that the data has more extreme outliers and a higher concentration of values around the mean. In statistical terms, such a distribution has a positive excess kurtosis value greater than zero.

83. (A) Skewness
Moments are mathematical values used to describe the characteristics of a distribution. The second central moment is used to calculate variance. The third central moment measures the asymmetry of the data around the mean. By standardizing the third central moment, statisticians calculate the coefficient of skewness, which provides a numerical value representing the direction and degree of the distribution's lack of symmetry.

84. (C) It is perfectly symmetrical.
The coefficient of skewness provides information about the balance of a distribution. A value of zero indicates that the data is distributed equally on both sides of the mean, meaning the distribution is perfectly symmetrical. In such cases, the mean, median, and mode will typically coincide at the same central value, and the left and right tails will be identical.

85. (A) Most leaves have few insects, while a few have extremely high counts.
Positive skewness occurs when a distribution has a long tail extending toward higher values. In entomology, many leaves might have zero or very few insects, but a small number of leaves could harbor very large populations. These occasional high counts pull the mean to the right of the median, creating a positively skewed distribution that is common in biological count data.

86. (D) Kurtosis
To determine if an empirical dataset follows a normal "bell-shaped" curve, researchers examine both skewness and kurtosis. While skewness checks for symmetry, kurtosis evaluates the weight of the tails. If the tails are too heavy or too light compared to a normal distribution, the kurtosis value will deviate from zero, indicating that the data might not meet the assumptions for certain parametric tests.

87. (A) $\frac{\text{Mean} - \text{Mode}}{\text{Standard Deviation}}$
Karl Pearson's coefficient of skewness is a standardized measure used to quantify the degree of asymmetry in a distribution. It is calculated by finding the difference between the mean and the mode and then dividing that value by the standard deviation. This formula provides a unitless coefficient where positive values indicate

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becomes larger, resulting in a smaller standard error.

69. (A) SD describes individual spread; SEM describes mean precision.
The standard deviation and the standard error provide different information about a dataset. The standard deviation describes the natural variability among individual observations within a single sample or population. In contrast, the standard error describes the uncertainty associated with the calculated mean itself. While standard deviation describes the data's spread, the standard error quantifies the reliability of the statistical estimate.

70. (D) SEM is a measure of dispersion of the underlying raw data.
The standard error of the mean is often misunderstood as a measure of data variability. However, it specifically describes the variability of the sample mean, not the individual raw observations. While it decreases as sample size increases and is used for confidence intervals, it is the standard deviation that is the appropriate statistic for describing the dispersion of the underlying raw experimental data.

71. (B) It decreases.
In experimental design, increasing the number of replications is a common strategy to improve the precision of treatment estimates. According to the mathematical formula, the standard error of the mean is inversely proportional to the square root of the sample size. Therefore, as more replicates are added, the standard error decreases, leading to more reliable estimates of the true treatment effects.

72. (C) Standard Error of the Mean
When evaluating the reliability of an estimated average, researchers use the standard error of the mean. This statistic provides a measure of how far the sample mean is likely to be from the true population mean. A smaller standard error indicates that the sample mean is a more precise and reliable representation of the population, facilitating more confident statistical inferences and comparisons.

73. (C) 3 kg
The standard error of the mean is calculated by dividing the sample standard deviation by the square root of the sample size. With a standard deviation of 15 kg and a sample size of 25, the square root of the size is 5. Dividing 15 by 5 results in a standard error of 3 kg, representing the precision of the calculated mean yield.

74. (A) SEM represents the statistical uncertainty in estimating the mean.
Scientific charts often use error bars to represent the standard error because it directly reflects the precision of the mean estimate shown on the graph. While the standard deviation shows the spread of raw data, the standard error is more relevant for hypothesis testing and showing the statistical confidence in the reported averages. It allows viewers to assess the likelihood of true differences.

75. (B) Describing the raw biological variability of individual plants
The standard error of the mean is used for making inferences about population parameters, such as constructing confidence intervals or performing t-tests. It is not intended to describe the actual variability of individual subjects in a population. To show the natural biological range or spread of traits among individual plants, the standard deviation is the correct and most appropriate statistic to use.

76. (B) Show the natural spread or variation of the trait within the population.
Researchers choose the standard deviation when their primary objective is to illustrate the diversity or spread of a trait among individuals. While the standard error focuses on the precision of the mean, the standard deviation provides a clear picture of how much individual observations deviate from that average. This is essential for understanding the natural variation within biological or agricultural populations.

77. (A) Standard deviation of the sample
As the sample size increases, certain statistics change significantly while others remain relatively stable. The sum of squares and variance of the mean are directly linked to the number of observations. However, the sample standard deviation is an estimate of a population parameter. In a well-mixed population, this estimate becomes more accurate but does not fundamentally change in magnitude as more data is collected.

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59. (B) Coefficient of Variation
Comparing the variability of traits measured in different units, such as crop yield in kilograms and plant height in centimeters, requires a dimensionless metric. Absolute measures like variance or standard deviation are not comparable due to their different units. The coefficient of variation eliminates units, providing a percentage that allows for a direct comparison of consistency and stability between diverse datasets.

60. (B) It ignores all values except for the two extremes.
The range is often an inadequate measure of dispersion because it is entirely determined by the maximum and minimum values in a dataset. It provides no information about the distribution or density of the data points between those two extremes. Furthermore, a single outlier can significantly inflate the range, giving a misleading impression of the overall variability of the population.

61. (A) The variance remains unchanged.
Variance measures the spread of data points relative to their mean. Adding a constant value to every observation shifts the entire distribution along the axis, which changes the mean by that same constant. However, the distance between the individual points and their new mean remains exactly the same as before. Therefore, the variance is independent of a change in the origin of data.

62. (C) 20%
The coefficient of variation is calculated by taking the ratio of the standard deviation to the mean and converting it to a percentage. In this case, with a standard deviation of 10 and a mean of 50, the ratio is 0.2. Multiplying by 100 results in a coefficient of variation of 20%, indicating the relative extent of variability in the sample data.

63. (D) Range
Dispersion measures vary in their sensitivity to outliers. The range is the most sensitive because it is defined exclusively by the two most extreme points. If a dataset contains an unrepresentative outlier, the range will reflect that single extreme value rather than the typical spread. In contrast, measures like the interquartile range are more robust as they ignore the extreme tails.

64. (A) Both A and R are true and R is the correct explanation of A.
Although variance is a key statistical concept, the standard deviation is more commonly reported in scientific literature. This preference exists because variance is expressed in squared units, which can be difficult to interpret physically. Since the standard deviation is the square root of variance, it returns to the original units of measurement, making it more practical for describing biological variability.

65. (B) It is multiplied by 2.
Standard deviation is a measure of spread that is sensitive to changes in scale. If every observation in a dataset is multiplied by a constant, the standard deviation is also multiplied by the absolute value of that same constant. This differs from variance, which would be multiplied by the square of the constant, reflecting the linear nature of the standard deviation metric.

66. (A) P-4, Q-1, R-2, S-3
Statistical measures of spread serve different interpretative purposes. The standard deviation calculates the average distance of observations from the mean. The standard error specifically measures the dispersion of sample means around the true population mean. Variance is the squared measure of this spread, while the coefficient of variation provides a relative metric to assess the consistency and reliability of the data.

67. (A) The standard deviation of the sampling distribution of the sample mean.
The standard error of the mean is a measure of the precision with which a sample mean estimates the population mean. It is defined as the standard deviation of the theoretical distribution that would be formed by the means of all possible samples of a given size. It quantifies how much the sample mean is expected to vary from the true population value.

68. (C) $\frac{s}{\sqrt{n}}$
The standard error of the mean is derived from the sample standard deviation and the sample size. It is calculated by dividing the standard deviation by the square root of the total number of observations. This formula demonstrates that the precision of the estimated mean increases as the sample size grows, because the denominator

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a right-skewed distribution and negative values indicate a left-skewed distribution.

88. (C) Platykurtic
Frequency distributions that are flatter than the normal distribution are known as platykurtic. These distributions have a lower peak and thinner tails, indicating that the observations are spread more widely and evenly across the range with fewer extreme outliers. In terms of mathematical coefficients, a platykurtic distribution is defined by having a negative excess kurtosis value less than zero.

89. (D) 3
In statistics, the absolute kurtosis of a normal distribution is equal to three. To make this measure easier to interpret, researchers often calculate "excess kurtosis" by subtracting three from the fourth standardized central moment. This adjustment centers the measure at zero, meaning that any positive value indicates a leptokurtic shape and any negative value indicates a platykurtic shape relative to normal.

90. (B) Mean < Median < Mode
A negatively skewed distribution is characterized by a long tail extending toward the lower values on the left side. This pulls the arithmetic mean down, making it the smallest of the three measures of central tendency. In such a distribution, the mode remains at the peak of the curve on the right, resulting in the hierarchy where the mean is less than the median.

91. (B) It warns against potential violations of normality assumptions.
Many powerful statistical tests, such as ANOVA, rely on the assumption that the data follows a normal distribution. If a dataset exhibits severe skewness, it is a clear sign that this assumption is violated. Identifying this early allows researchers to apply appropriate data transformations or use non-parametric alternatives, ensuring that the results of their analysis remain valid and reliable.

92. (B) A specific success count in a fixed number of independent trials.
The Binomial distribution is a discrete probability model used for situations where there are only two possible outcomes, such as success or failure. It calculates the probability of obtaining a specific number of successes in a set number of independent trials. This distribution is fundamental for analyzing data involving proportions, germination rates, or the presence and absence of traits in genetics.

93. (A) Probability of success (p) and sample size (n)
A Binomial distribution is completely determined by two parameters: the total number of trials and the constant probability of success in each individual trial. Once these two values are known, the mean, variance, and the probability of every possible outcome can be mathematically calculated. These parameters define the entire shape and location of the distribution curve for discrete variables.

94. (C) np
The theoretical mean of a Binomial distribution represents the expected number of successes across a series of trials. It is calculated by multiplying the total number of trials by the probability of success for a single trial. This simple product provides the average outcome researchers would expect to observe if the experiment were repeated many times under identical conditions in the population.

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95. (D) Binomial variance is strictly greater than the mean.
The variance of a Binomial distribution is calculated by multiplying the number of trials by the probability of success and the probability of failure. Since the probability of failure is always a fraction less than one, the resulting variance must always be smaller than the mean. The statement claiming that the variance is greater than the mean is mathematically incorrect for this distribution.

96. (C) 8.0
For a Binomial distribution, the expected mean is found by multiplying the number of trials by the probability of success. In an experiment where ten seeds are sown and each has an eighty percent chance of germinating, the expected number of germinated seeds is eight. This represents the long-term average outcome researchers would expect from such an experimental setup across multiple trials.

97. (A) 5
The variance of a Binomial distribution is determined by the formula npq, where p is the probability of success and q is the probability

with independent events occurring at a constant average rate over time.

117. (A) Probability of success in a single trial is exceedingly small.
The Poisson distribution is often called the "law of improbable events" because it models situations where there are a vast number of opportunities for an event to occur, but the probability of it actually happening in any single instance is very low. This makes it ideal for modeling rare biological occurrences where many individuals are present, but the event is infrequent.

118. (D) Mean and variance
The normal distribution is a continuous probability distribution characterized by its symmetrical, bell-shaped curve. It is completely defined by two parameters: the arithmetic mean, which identifies the center of the distribution, and the variance, which determines the spread or width of the curve. These two values provide all the information necessary to describe the entire distribution and calculate specific probabilities.

119. (B) Mean = 0, Variance = 1
The standard normal distribution is a specific version of the normal distribution used as a universal reference in statistics. It is defined by having a mean of exactly zero and a variance of exactly one. This standardization allows for the creation of universal probability tables, which can be used to analyze any normal variable once it has been transformed into Z-scores.

120. (C) $Z = \frac{X - \mu}{\sigma}$
To use standard normal probability tables, an original normal variable must be transformed into a Z-score. This is achieved by subtracting the population mean from the individual observation and then dividing the result by the standard deviation. This process centers the data at zero and scales it based on the standard deviation, resulting in a dimensionless value that represents the distance from the mean.

121. (B) Approximately 68.3%
In a normal distribution, the area under the curve represents the probability of observations falling within certain limits. According to the empirical rule, approximately sixty-eight point three percent of the total data lies within one standard deviation above and below the mean. This consistent property is used by researchers to identify the range where the majority of observations in a normal population are located.

122. (A) The curve touches the horizontal axis at exactly 3 standard deviations from the mean.
The normal distribution is defined by a mathematical function that is asymptotic to the horizontal axis. This means that while the curve gets closer and closer to the axis as it moves away from the mean, it theoretically never actually touches or crosses it. The curve extends to infinity in both directions, although the probability of observations beyond three standard deviations is very small.

123. (B) 95%
The normal distribution has standardized probability limits that are frequently used in hypothesis testing. One of the most important limits is the range of one point nine six standard deviations on either side of the mean, which encompasses exactly ninety-five percent of the area under the curve. This value is the basis for the five percent significance level used in research.

124. (A) Both A and R are true and R is the correct explanation of A.
The standard normal distribution is a powerful tool because it provides a common scale for comparing different variables. By using the Z-transformation, researchers can convert any normal variable, regardless of its original units or mean, into a standardized score. This score indicates how many standard deviations a value is from the mean, allowing for universal probability calculations for diverse datasets.

125. (A) 0.50
The normal distribution is perfectly symmetrical about its mean. Since the total area under any probability density curve must equal one, the mean divides the distribution into two equal halves. Therefore, the probability that an observation falls anywhere above the mean is exactly zero point five, regardless of the distribution's specific mean or variance values.

126. (A) P-3, Q-4, R-1, S-2
Standard normal probability tables define the area enclosed between specific Z-score limits. One standard deviation covers about sixty-eight percent, while one point nine six standard deviations cover ninety-five percent

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107. (C) Mean = Variance
A unique and fundamental property of the Poisson distribution is that its theoretical mean is exactly equal to its variance. This means that as the average rate of occurrence increases, the spread or variability of the data also increases proportionally. This characteristic is a key diagnostic tool used by statisticians to determine if a set of count data follows a Poisson model.

108. (B) $n \to \infty$ and $p \to 0$, such that np is constant
The Poisson distribution is mathematically related to the Binomial distribution as a limiting case. When the number of trials becomes very large and the probability of success in each trial becomes very small, the Binomial distribution converges to a Poisson distribution. In this transition, the product of n and p remains constant and becomes the mean parameter of the Poisson model.

109. (B) I
The Poisson distribution is widely used in biological research to model the frequency of rare, independent events. It is a discrete distribution, meaning it only applies to whole integer counts. Its unique property is that the mean and variance are equal, not that the variance is larger. Among the given statements, only its application to DNA mutations is correct, as mutations are rare events.

110. (C) Counting the number of weed seeds found in a 1 kg sample of crop seed
Count data involving rare occurrences within a large volume or weight are typical candidates for the Poisson distribution. Since weed seeds are usually very few relative to the total number of seeds in a large sample, their count is a discrete variable that occurs randomly. The Poisson model effectively estimates the probability of finding zero, one, or more weed seeds in samples.

111. (D) 4
The Poisson distribution possesses the distinctive mathematical property where the mean is equal to the variance. If the average number of bacterial colonies per dish is four, then the variance of that count across multiple dishes is also four. This equality allows researchers to estimate the variability of the counts directly from the observed average rate without additional complex calculations.

112. (C) It allows for data transformation to stabilize variances.
Recognizing that data follows a Poisson distribution is useful because the mean and variance are linked. In ANOVA, this relationship violates the assumption of constant variance across treatments. Knowing the data is Poisson-distributed allows researchers to apply a square-root transformation. This mathematical adjustment stabilizes the variance, making the transformed data suitable for standard parametric statistical tests like Analysis of Variance.

113. (B) Weight of apples harvested from a single tree
The Poisson distribution is strictly used for discrete count data. Typological errors, hailstorms, and nematode cysts are all whole numbers that result from counting occurrences of independent events. In contrast, the weight of a harvest is a continuous variable measured on a numerical scale. Continuous variables are better modeled by the normal distribution rather than discrete models like the Poisson distribution.

114. (D) 3
In any Poisson distribution, the mean and variance are identical by definition. Therefore, if the variance of a Poisson random variable is known to be three, the expected mean must also be three. This relationship is a defining feature of the distribution and is used to simplify the process of statistical modeling for counts of rare, independent occurrences in intervals.

115. (A) As the mean (λ) becomes sufficiently large
The Poisson distribution is naturally skewed to the right, especially when the mean rate is low. However, as the value of the mean parameter lambda increases, the distribution becomes increasingly symmetrical. When lambda is large, typically above twenty, the Poisson distribution closely approximates the shape of a normal distribution, allowing for the use of more standard parametric statistical methods in analysis.

116. (C) 2.718
The probability mass function of the Poisson distribution includes the mathematical constant 'e', which is the base of the natural logarithm. This irrational number is approximately equal to two point seven one eight. It plays a critical role in describing exponential growth and decay processes, as well as the probabilities associated

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of failure. With twenty trials and a fifty percent success rate, both p and q are zero point five. Multiplying twenty by zero point five and then by zero point five again results in a variance of exactly five.

98. (D) Each trial has exactly two mutually exclusive outcomes.
The Binomial distribution is strictly applicable only when certain conditions are met. Each trial must result in one of exactly two outcomes, such as "yes/no" or "survived/died." Additionally, the trials must be independent of one another, and the probability of success must remain constant throughout the experiment. If these criteria are not met, the Binomial model cannot be accurately applied.

99. (A) When $p = 0.5$, regardless of n
The symmetry of a Binomial distribution depends on the probability of success. When the probability of success and failure are exactly equal at zero point five, the distribution is perfectly symmetrical. If the probability of success deviates from this center, the distribution becomes skewed. However, as the number of trials increases, even skewed Binomial distributions gradually begin to appear more symmetrical.

100. (A) III, I, IV, II
Calculating a Binomial probability involves a logical sequence of operations. First, the probability of a single success must be identified. Next, the number of trials and required successes are determined. The number of possible combinations is then calculated, and finally, this result is multiplied by the success and failure probabilities raised to their respective powers to find the final probability value.

101. (A) Binomial distribution
When an agricultural researcher evaluates a fixed number of independent locations for a binary outcome, such as the presence or absence of a pathogen, the Binomial distribution is the most appropriate model. Each field represents an independent trial with two possible results. The total number of infected fields follows this discrete distribution, allowing the researcher to calculate the probability of different infection levels.

102. (D) Multiplying the mean (np) by $q < 1$ reduces the value.
The mathematical structure of the Binomial distribution ensures that the variance is always smaller than the mean. The mean is defined as np, while the variance is npq. Because the probability of failure, q, is always a value between zero and one, multiplying the mean by q must result in a smaller number. This inherent property distinguishes the Binomial from other distributions.

103. (B) Calculating the probability of 3 dwarfs in 10 progeny.
Plant breeding often involves discrete outcomes in a fixed number of offspring, such as the appearance of a specific trait like dwarfism. If the probability of the trait is known, the Binomial distribution can be used to calculate the exact likelihood of seeing a specific number of affected plants in a small progeny group, making it an essential tool for genetic analysis.

104. (C) 0.6
In a Binomial distribution, the mean is np and the variance is npq. By dividing the variance by the mean, the value of q can be determined. For a distribution with a mean of four and a variance of two point four, dividing two point four by four gives zero point six. This value represents the probability of failure for each trial in the dataset.

105. (D) Rare events occurring randomly in a fixed time/space interval.
The Poisson distribution is a discrete probability model designed for counting occurrences of events that happen independently and at a constant average rate. It is specifically used for rare events within a defined continuous interval, such as time, area, or volume. Examples include the number of insects found on a single leaf or the occurrence of storms during a specific season.

106. (A) Mean rate of occurrence (λ or m)
Unlike the Binomial distribution which requires two parameters, the Poisson distribution is completely defined by a single parameter, often denoted as lambda. This parameter represents the average number of events occurring in the given interval. Once lambda is known, it serves as both the mean and the variance of the distribution, entirely determining the probability of all possible counts.

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of the data. Two point five eight standard deviations encompass ninety-nine percent, and three standard deviations include ninety-nine point seven three percent. These constants are essential for determining the confidence levels of experimental results.

127. (D) 0
In a continuous probability distribution like the normal distribution, the probability is defined as the area under the curve over an interval. Because an individual point has no width, the area exactly above that single point is zero. Therefore, while we can calculate the probability of a value falling within a range near the mean, the mathematical probability of it being exactly the mean is zero.

128. (C) The PDF uses an exponential function that never reaches zero.
The normal distribution is defined by an equation that includes a negative exponential of the squared distance from the mean. Mathematically, an exponential function of a real number can approach zero as the exponent becomes very large but will never actually reach it. This ensures that the tails of the theoretical distribution are infinite, representing a tiny but non-zero probability for extreme values.

129. (A) I and IV
Understanding the nature of probability distributions is vital for analysis. The Binomial distribution is discrete, not continuous, as it deals with counts of successes. Furthermore, the standard normal curve is defined by a mean of zero, not one. In contrast, the normal distribution is correctly described as continuous, and the Poisson distribution is corrected classified as a discrete model for counting events.

130. (D) It lies 2.5 standard deviations below the population mean.
A Z-score represents a standardized distance from the mean in units of standard deviations. A negative sign indicates that the value is below the mean, while a positive sign indicates it is above. Therefore, a Z-score of negative two point five identifies a data point that is specifically located two and a half standard deviations to the left of the population average yield.

131. (A) The degree and direction of linear association
Simple correlation is a statistical tool used to determine the relationship between two continuous variables. It specifically measures the extent to which the variables change together in a linear fashion. The correlation indicates both the strength of this association and the direction, showing whether the variables increase together or if one increases while the other decreases in a predictable, straight-line manner.

132. (C) -1 and +1
Pearson's correlation coefficient is a standardized value that represents the strength of a linear relationship. The coefficient is mathematically constrained to stay within the range of negative one and positive one. A value of positive one indicates a perfect direct linear relationship, while negative one indicates a perfect inverse relationship. A value of zero suggests that no linear association exists between the variables.

133. (A) Data contains outliers or is measured on an ordinal scale.
Spearman's rank correlation is a non-parametric alternative to Pearson's correlation. It is particularly useful when the data does not meet the assumption of normality or contains extreme outliers that could distort the results. Because it uses the ranks of the data rather than the actual values, it effectively measures the monotonic relationship between variables regardless of their distribution or measurement scale.

134. (D) It is independent of both change of origin and scale.
The correlation coefficient is a unitless measure of association. A significant mathematical property of this coefficient is that its value remains unchanged even if a constant is added to every observation or if all observations are multiplied by a positive constant. This independence from changes in origin and scale makes correlation a robust and versatile tool for comparing relationships across different measurement systems.

135. (B) A correlation coefficient of exactly 0 proves the two variables are entirely independent in every way.
Pearson's correlation coefficient specifically measures linear association. If the coefficient is zero, it only indicates that there is no linear relationship between the variables; however,

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a strong non-linear or curvilinear relationship might still exist. Furthermore, correlation describes association rather than causation, and its calculation is related to the geometric mean of the regression coefficients for the two variables being studied.

136. (C) A lurking third variable influences both measured traits.
A spurious correlation occurs when two variables appear to be related, but the association is actually caused by the influence of an unmeasured third factor. This third variable affects both measured traits simultaneously, creating a statistical link that does not reflect a direct relationship. Researchers must be careful not to mistake these types of coincidental or indirect associations for true cause-and-effect dependencies.

137. (D) Negative linear correlation
A negative correlation exists when two variables move in opposite directions. In agricultural contexts, if increasing the amount of fertilizer consistently leads to a decrease in soil pH, the variables are said to be negatively correlated. This inverse relationship indicates that as one value rises on the measurement scale, the other falls, resulting in a downward-sloping trend line when the data is plotted.

138. (A) 0
Pearson's correlation coefficient is calculated by dividing the covariance of two variables by the product of their individual standard deviations. Covariance measures the joint variability of the variables. If the covariance is zero, it means there is no shared linear movement between them. Consequently, the numerator in the correlation formula becomes zero, resulting in a correlation coefficient of exactly zero.

139. (B) Correlation indicates association strength; regression provides a predictive equation.
While correlation and regression are related, they serve different analytical purposes. Correlation focuses on the degree and direction of the association between variables without assuming a cause-and-effect direction. Regression, however, identifies one variable as independent and the other as dependent. It produces a mathematical equation that allows researchers to predict the value of the dependent variable based on changes in the independent predictor.

140. (B) -0.90
The strength of a linear relationship is determined by the absolute value of the correlation coefficient, regardless of its sign. A coefficient of negative zero point nine zero indicates a very strong inverse linear relationship, which is mathematically stronger than positive associations of zero point seven five or zero point eight eight. The closer the value is to either positive or negative one, the stronger the association.

141. (A) t-test with $n-2$ degrees of freedom
To determine if an observed sample correlation is statistically significant, researchers typically perform a t-test. The null hypothesis states that the true population correlation is zero. The test statistic is calculated using the sample correlation and the sample size, and it follows a t-distribution with n minus two degrees of freedom. This allows statisticians to determine if the relationship is likely to exist in the population.

142. (C) 0.64
The coefficient of determination is calculated by squaring the simple correlation coefficient. It represents the proportion of the total variation in the dependent variable that can be explained by its linear relationship with the independent variable. If the correlation coefficient is zero point eight, then squaring it results in zero point six four, meaning that sixty-four percent of the variation is accounted for by the model.

143. (D) r will be exactly 1.0
If two variables are identical, they will have a perfect positive linear relationship because they will always increase and decrease at exactly the same rate. In the correlation formula, the covariance between a variable and itself is equal to its variance. This results in a numerator and denominator that are identical, leading to a correlation coefficient of exactly positive one point zero for any variable compared to itself.

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144. (C) Removing the linear effect of other variables.
Partial correlation measures the direct association between two variables while mathematically controlling for the influence of one or more additional variables. This technique allows researchers to isolate the specific relationship between two factors by removing the confounding effects of other variables that might be influencing both. It is essential for

uncovering the true nature of associations in complex agricultural systems.

145. (B) A dependent variable and the combined linear effect of two or more independent variables.
Multiple correlation describes the overall strength of the relationship between a single dependent variable and a group of two or more independent predictors. It quantifies how well the combined set of variables can explain the variation in the response. The multiple correlation coefficient is always positive and provides a measure of the collective predictive power of the entire regression model.

146. (C) $n-3$
The degrees of freedom for testing the significance of a partial correlation coefficient depend on the sample size and the number of variables being held constant. For a first-order partial correlation, where one variable is controlled, the formula is n minus three. In general, the degrees of freedom are calculated as the sample size minus the total number of variables involved in the partial correlation calculation.

147. (A) It ranges only between 0 and 1.
The multiple correlation coefficient is always a non-negative value between zero and one. Because it measures the collective relationship between a dependent variable and a set of predictors, it does not have a direction like simple correlation. A value of one indicates that the predictors perfectly account for all the variation in the dependent variable, while zero indicates no joint relationship exists.

148. (C) First-order controls for an extra variable; zero-order is simple.
The order of a correlation coefficient refers to the number of variables being controlled or held constant. A zero-order correlation is a simple correlation between two variables without any controls. A first-order partial correlation measures the relationship between two variables while controlling for the effect of a third variable. As more variables are controlled, the order of the partial correlation increases accordingly.

149. (B) I, III and IV
Multiple and partial correlations provide deep insights into multivariate data. The multiple correlation coefficient R cannot be smaller than any of the individual simple correlations. Partial correlation is a vital tool for identifying spurious relationships by controlling for confounding variables. Furthermore, the square of the multiple correlation coefficient correctly represents the proportion of total variation explained by the combined set of predictors.

150. (D) The partial correlation between yield and rainfall, holding fertilizer constant.
Statistical notation for partial correlation clearly identifies which variables are being studied and which are being controlled. In the notation provided, the primary relationship is between yield and rainfall. The value after the dot indicates the variable that is being held constant or controlled. This allows the researcher to determine the direct impact of rainfall on yield after removing the confounding effect of fertilizer.

151. (B) The fitting process uses chance sample variation to reduce error.
When more independent variables are added to a multiple regression model, the multiple correlation coefficient R often increases even if the new variables are not meaningful. This happens because the mathematical model uses random noise and unique sample variations to improve the fit to the data. To account for this artificial inflation, statisticians often use adjusted measures that penalize the addition of unnecessary variables.

152. (C) Second-order partial correlation
The classification of partial correlation depends on the number of variables whose effects are being removed. If two variables are being held constant while measuring the association between two others, it is referred to as a second-order partial correlation. This type of analysis is common in multivariate agricultural research where multiple factors, such as temperature and soil moisture, may simultaneously influence a trait.

153. (D) It isolates direct trait relationships by removing confounding.
In complex agricultural experiments, multiple traits are often interrelated, making it difficult to identify direct cause-and-effect paths. Partial correlation is advantageous because it mathematically strips away the indirect influences of other factors. This isolation allows researchers to determine if an observed association between two variables is direct or if it

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ANOVA is functionally identical to a two-tailed independent t-test with pooled variance and equal assumptions.

191. (D) Has a shape that depends entirely on two degrees of freedom parameters.
Unlike the normal distribution, which is defined by its mean and variance, or the t-distribution, which uses one degree of freedom, the F-distribution is defined by two degrees of freedom. These values correspond to the numerator and denominator of the variance ratio. Because of this, the F-distribution is more complex and its shape changes significantly depending on the sizes of both samples involved.

192. (C) Test multiple means together without inflating alpha risk.
The F-test in ANOVA is powerful because it can evaluate the equality of several group means simultaneously. If a researcher used multiple t-tests to compare every pair of means, the risk of a Type I error would increase with each test. The F-test provides a single, overall test of the null hypothesis, controlling the significance level for the entire experiment in one operation.

193. (B) At least one population mean is significantly different from the others.
When Snedecor's F-test in a one-way ANOVA yields a significant result, it means the observed variation between the treatment means is too large to be explained by chance. This allows the researcher to reject the null hypothesis that all group means are equal. However, the F-test does not identify which specific means are different; that requires further analysis using post-hoc tests.

194. (D) 0
The F-statistic is calculated as a ratio of two variances. Since variance represents the average of squared deviations, it can never be a negative number. Because both the numerator and the denominator in the F-ratio are always non-negative, the resulting value of the F-statistic must also be non-negative. Therefore, the minimum possible value that an F-statistic can attain is zero.

195. (A) The treatment mean square is roughly equal to the error mean square, indicating no true treatment effect.
An F-ratio near one indicates that the amount of variation between the treatments is similar to the amount of variation within the treatments (error). This suggests that any observed differences between the means are likely due to random chance rather than the treatments themselves. In such cases, the null hypothesis is typically not rejected, as there is no evidence of a significant treatment effect.

196. (C) Counted categorical or frequency data
The Chi-square statistic is a non-parametric tool used for analyzing discrete data that consists of frequencies or counts within categories. It is not intended for continuous measurements like height or weight. instead, it evaluates how well observed counts in different categories, such as plant phenotypes or disease presence, match the counts that would be expected under a specific null hypothesis or ratio.

197. (B) $\frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$
The Chi-square test is based on the difference between observed frequencies and the frequencies expected under the null hypothesis. To calculate the statistic, each difference is squared to eliminate negative signs and then divided by the expected frequency to standardize the value. These standardized squared differences are summed across all categories to produce the final Chi-square value used for statistical testing.

198. (D) The observed data must consist of percentages or ratios, not raw counts.
A fundamental requirement for the Chi-square test is that the data must be in the form of raw frequencies or actual counts of observations. Using percentages, proportions, or ratios directly in the formula will result in an incorrect and invalid test statistic. Other essential conditions include having a sufficiently large sample size and ensuring that the categories are independent and mutually exclusive.

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199. (B) Correcting the continuous approximation of discrete frequencies.
The Chi-square distribution is a continuous theoretical model, but it is being used to analyze discrete count data. This can lead to inaccuracies, particularly in small datasets like a two-by-two

the risk of a Type I error by lowering the significance level, the criteria for rejecting the null hypothesis become more stringent. This increased strictness makes it more likely that the test will miss small but real effects, thereby increasing the probability of committing a Type II error.

164. (C) Power of the test
The power of a statistical test is the probability that it will correctly reject a false null hypothesis. It is mathematically calculated as one minus the probability of a Type II error. A high-powered test is more likely to detect genuine treatment differences if they exist. Power is influenced by factors such as sample size, the level of significance, and the magnitude of the effect.

165. (C) $\mu_{new} > \mu_{check}$
A one-tailed test is used when a researcher has a specific directional prediction about the outcome of an experiment. If a new crop variety is expected to be superior to a standard variety, the alternative hypothesis specifically states that the mean yield of the new variety is greater than the check. This concentrates all the statistical power on detecting a difference in that single direction.

166. (D) It splits the alpha risk into both tails, requiring more extreme values.
A two-tailed test is more conservative than a one-tailed test because it divides the total significance level between both ends of the probability distribution. For a five percent level, each tail only gets two point five percent. This means that an observed difference must be more extreme to be considered significant, making it harder to reject the null hypothesis than in a directional one-tailed test.

167. (B) Increasing the sample size
Increasing the number of observations is the most effective way to reduce the risk of both Type I and Type II errors. A larger sample size provides a more precise estimate of the population parameters and reduces the standard error. This makes the statistical test more sensitive and powerful, allowing it to detect real differences more reliably while simultaneously decreasing the likelihood of results being due to chance.

168. (C) Type I error
When a researcher incorrectly concludes that a treatment is effective when no true benefit exists, they have committed a Type I error. In this scenario, the null hypothesis of "no benefit" is actually true, but the researcher has rejected it in favor of a false claim of superiority. This error represents a false discovery and is the primary risk controlled by the level of significance.

169. (D) Reject the null as the data probability is below the threshold.
The p-value represents the probability of obtaining the observed results if the null hypothesis were true. If the calculated p-value is less than the pre-determined significance level, such as zero point zero five, the result is considered statistically significant. Since a p-value of zero point zero three is below the threshold, the researcher should reject the null hypothesis and support the alternative.

170. (A) Small sample sizes ($n < 30$) and unknown population variance.
Student's t-distribution is a family of probability distributions used for small sample hypothesis testing. It is particularly appropriate when the sample size is less than thirty and the true population variance is unknown. In these cases, the standard deviation of the sample must be used to estimate the standard error, making the t-distribution a more accurate model than the standard normal distribution.

171. (B) $n - 1$
Degrees of freedom represent the number of independent pieces of information used to estimate a statistical parameter. In a one-sample t-test, the degrees of freedom are calculated as the total number of observations minus one. This is because one degree of freedom is used up when calculating the sample mean, which is necessary to estimate the variance used in the t-test formula.

172. (B) Independent two-sample t-test
An independent two-sample t-test is used to compare the means of two groups that have no relationship with each other. In agriculture, this is common when comparing plots in two different fields or treatments assigned to separate groups of plants. The test evaluates if the difference between the two sample means is significant

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enough to suggest that the underlying population means are different.

173. (A) The sample sizes of the two groups must be exactly equal.
While having equal sample sizes can simplify calculations and make a t-test more robust against variance differences, it is not a requirement for the test to be valid. The independent two-sample t-test can accommodate groups with different numbers of observations. However, other assumptions, such as independent samples, normally distributed populations, and homogeneity of variances, must still be met to ensure accurate results.

174. (C) Observations are taken on the same subjects, creating correlation.
A paired t-test is used when there is a natural link between the observations in the two groups. This commonly occurs in "before-and-after" studies or when measurements are taken on the same individual or paired locations. Because the observations are correlated, the variability between the pairs can be removed from the analysis, making the test more sensitive to the actual treatment effect.

175. (B) $n_1 + n_2 - 2$
In an independent two-sample t-test where population variances are assumed to be equal, a pooled variance is calculated. The degrees of freedom for this pooled estimate are found by summing the degrees of freedom for each sample. Since each individual sample contributes n minus one degrees of freedom, the total for the combined test is the sum of both sample sizes minus two.

176. (C) The assumption of equal population variances is significantly violated.
The standard t-test assumes that the two populations being compared have equal variances. If this assumption is violated, especially with unequal sample sizes, the results of the standard test can be misleading. Welch's t-test is a modification that adjusts the degrees of freedom and the standard error calculation to account for unequal variances, providing a more reliable result in these situations.

177. (B) Isolate treatment effects by removing biological variation.
The paired t-test is highly advantageous in agricultural research because it allows for the control of background variability. By applying two treatments to similar units, such as different branches of the same tree or adjacent plots, the researcher can account for differences in soil or genetics. This focuses the analysis on the difference within each pair, making it easier to detect significant treatment effects.

178. (D) Reject the null hypothesis, indicating a significant difference exists.
Hypothesis testing involves comparing a calculated test statistic to a theoretical critical value from a distribution table. When the absolute value of the calculated t-statistic exceeds the critical value at a chosen significance level, the evidence is sufficient to reject the null hypothesis. This indicates that the observed difference between paired treatment means is statistically significant and likely not due to random chance.

179. (A) Population correlation coefficient
To calculate the t-statistic for an independent two-sample test, the researcher needs the means, variances, and sizes of both samples. These values are used to estimate the standard error of the difference. Because the two groups are assumed to be independent, there is no correlation between them. Therefore, a population correlation coefficient is not part of the formula or the requirements for this test.

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180. (A) I, II, III, IV
Conducting a t-test follows a logical progression of steps to ensure statistical validity. First, the null and alternative hypotheses are clearly stated. Then, the t-statistic is calculated from the sample data. The appropriate degrees of freedom are determined next, and finally, the calculated value is compared to a critical value from a statistical table to reach a final conclusion about significance.

181. (A) The curve precisely approaches the standard normal distribution curve.
The shape of the t-distribution depends on the degrees of freedom. With small samples, the t-distribution has thicker tails and a lower peak than the normal distribution. However, as the degrees of freedom increase, the estimate of the

standard deviation becomes more precise. When the degrees of freedom approach infinity, the t-distribution becomes mathematically identical to the standard normal distribution curve.

182. (D) The set of differences calculated between the paired observations.
A paired t-test simplifies the comparison of two correlated groups by focusing on the difference between each pair. Instead of analyzing two separate sets of data, the researcher calculates a single value for each pair by subtracting one observation from the other. A one-sample t-test is then performed on these difference values to determine if their average is significantly different from zero.

183. (B) Variances
Snedecor's F-test is a statistical procedure designed to compare the variability of two different populations. It is fundamentally used to test the null hypothesis that two population variances are equal. This test is essential for checking the assumptions of other tests, such as the independent t-test, and forms the core of Analysis of Variance, where multiple sources of variation are compared.

184. (A) Both A and R are true and R is the correct explanation of A.
When performing an F-test manually, it is standard practice to place the larger sample variance in the numerator and the smaller one in the denominator. This ensures that the resulting F-ratio is always greater than or equal to one. Since most standard F-distribution tables are designed for one-tailed tests focused on values above one, this convention simplifies the process of determining statistical significance.

185. (D) Positively skewed and taking only non-negative values
The F-distribution is defined as the ratio of two independent chi-square variables. Because variances and squared values are always non-negative, the F-statistic cannot be less than zero. The distribution curve starts at the origin, reaches a peak, and has a long tail extending to the right. This positive skewness is a defining characteristic of the F-distribution shape, which changes based on degrees of freedom.

186. (A) P-1, Q-3, R-2, S-4
Different statistical tests are specialized for specific types of data and hypotheses. The F-test is primarily used for comparing variances and multiple means in ANOVA. The paired t-test is used for correlated samples. The Chi-square test evaluates categorical frequencies and goodness of fit. Finally, the Z-test is appropriate for hypothesis testing when the population variance is known and the sample size is large.

187. (B) Treatment mean square to error mean square
In the context of ANOVA, the F-statistic is used to determine if the differences between treatment means are significantly greater than the differences expected by random chance. It is calculated by taking the ratio of the treatment mean square, which represents variation between groups, to the error mean square, which represents variation within groups. A large F-ratio suggests that the treatment effects are genuine.

188. (B) It requires two distinct degrees of freedom: $v_1 = n_1 - 1$ for the numerator and $v_2 = n_2 - 1$ for the denominator.
The F-distribution is unique because its shape is determined by two separate degrees of freedom parameters. When comparing two variances, the first parameter corresponds to the sample used in the numerator of the F-ratio, and the second corresponds to the denominator. Both values are required to locate the correct critical value in an F-table, as both affect the distribution's probability density.

189. (A) To test the assumption of homoscedasticity (equal population variances).
Before performing an independent t-test, it is important to verify that the groups being compared have similar variances, a condition known as homoscedasticity. If the variances are significantly different, the results of a standard t-test may be invalid. An F-test is used to compare the two sample variances; if the result is not significant, the researcher can proceed with the standard t-test.

190. (C) $F = t^2$
There is a direct mathematical link between the t-distribution and the F-distribution when comparing exactly two groups. In this specific case, the F-statistic is equal to the square of the t-statistic. This relationship exists because the F-test for two means in a one-way

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is merely a byproduct of their shared relationship with another confounded variable.

154. (A) It becomes zero or mathematically undefined due to collinearity.
If two variables in a partial correlation analysis are perfectly correlated with each other, they provide redundant information. This condition, known as perfect collinearity, causes the mathematical calculation for partial correlation to fail. The formula involves dividing by values that become zero when variables are identical, leading to an undefined result. This highlights the problems that arise when predictors are too closely related.

155. (B) $1 - R^2_{\{1.23\}}$
The coefficient of determination represents the proportion of variance explained by a set of predictor variables. Since the total variation in a variable is defined as one hundred percent, the portion that is not accounted for by the predictors is calculated by subtracting the squared multiple correlation coefficient from one. this remaining value represents the unexplained variation or residual error in the model.

156. (C) $r_{\{12.3\}} = r_{\{12\}}$
If a third variable has no relationship with either of the two primary variables, it cannot confound or influence their association. Mathematically, controlling for an unrelated variable does not change the covariance or the individual variances involved in the correlation. Therefore, the partial correlation between the first two variables will be exactly equal to their simple, zero-order correlation in the dataset.

157. (A) No difference, no effect, or status quo.
The null hypothesis is a starting assumption used in statistical testing. It proposes that any observed differences or effects in experimental data are purely the result of random sampling chance rather than a true underlying cause. By assuming that no real change or treatment effect exists, researchers can use probability to determine if their findings are significant enough to reject this assumption.

158. (C) The hypothesis claiming there is a true effect or difference in the population.
The alternative hypothesis is the statement that researchers hope to support with their data. It contradicts the null hypothesis by proposing that there is a genuine treatment effect, a relationship between variables, or a significant difference between groups in the population. A statistical test is designed to evaluate if the evidence is strong enough to favor the alternative over the null.

159. (D) Rejects a true null hypothesis.
A Type I error, also known as a false positive, occurs when a researcher concludes that a significant effect exists when, in reality, it does not. This happens if the null hypothesis is actually true but is rejected because the sample data yielded an extreme result by pure chance. Controlling the risk of this error is a fundamental part of setting the significance level.

160. (C) α (Level of significance)
The probability of committing a Type I error is represented by the Greek letter alpha. This value is also known as the level of significance and is pre-determined by the researcher before conducting the test. By setting alpha, usually at five percent, the researcher defines the maximum risk they are willing to take of incorrectly rejecting a true null hypothesis during their analysis.

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161. (B) The alternative hypothesis is true, but the null hypothesis is not rejected.
A Type II error, or false negative, occurs when a statistical test fails to detect a genuine effect that actually exists in the population. This happens when the null hypothesis is false, but the researcher does not reject it based on the sample data. This error often results from a small sample size or high variability, leading to a lack of statistical power.

162. (D) It is the risk of concluding a difference exists when none does.
The level of significance defines the threshold for rejecting the null hypothesis. It represents the maximum allowable probability of committing a Type I error. In practical terms, it is the risk a researcher accepts of declaring a scientific finding significant when the observed results are actually just due to random variation. It is a critical part of the conservative nature of statistical testing.

163. (A) Lowering alpha risk makes it harder to detect a true difference.
Type I and Type II errors are linked for any fixed sample size. If a researcher tries to reduce

contingency table. Yates' continuity correction is a mathematical adjustment that compensates for this discrepancy between a discrete variable and a continuous distribution, providing a more conservative and accurate p-value.

200. (A) II, III, I, IV
Performing a Chi-square test for independence requires a structured sequence of mathematical steps. The process begins with formulating a null hypothesis of independence between two categorical variables. Expected frequencies are then calculated for each cell based on marginal totals. Finally, the squared differences between observed and expected values are computed and summed to determine the test statistic, which is compared to critical values.

201. (D) It subtracts 0.5 from the absolute difference between observed and expected frequencies before squaring.
Yates' correction is applied specifically to two-by-two contingency tables. It involves reducing the absolute difference between each observed and expected frequency by zero point five before the value is squared in the Chi-square formula. This adjustment reduces the magnitude of the calculated Chi-square statistic, making the test more conservative and preventing the overestimation of significance when sample sizes are relatively small.

202. (C) $(r-1)(c-1)$
The degrees of freedom for a Chi-square contingency table reflect the number of cell frequencies that are free to vary given the fixed marginal totals. For a table with 'r' rows and 'c' columns, the degrees of freedom are calculated by multiplying one less than the number of rows by one less than the number of columns. This value determines the correct distribution curve for comparison.

203. (A) Goodness-of-fit assesses distribution matching for one variable; independence assesses association between two variables.
Chi-square tests are used in two primary ways. The goodness-of-fit test evaluates if a single categorical variable follows a specific theoretical distribution, such as a genetic ratio. The test of independence evaluates whether two different categorical variables are related or if they occur independently of one another. Both tests use similar formulas but are applied to different types of experimental questions in research.

204. (B) Provides a completely parameter-free approach for testing associations in qualitative data.
A major advantage of the Chi-square test is that it does not require the data to follow a specific distribution like the normal distribution. As a non-parametric test, it is highly flexible and can be applied to qualitative or nominal data that cannot be analyzed with t-tests or ANOVA. This makes it an essential tool for studying associations in genetics and surveys.

205. (A) Testing whether the variance of crop yield differs between two fields.
The Chi-square test is used for frequency-based analysis of categorical data. It is suitable for genetic ratios, categorical associations in contingency tables, and testing if a die is fair. However, testing the equality of variances for continuous data like crop yield requires an F-test. The Chi-square test cannot be directly used to compare the variances of two independent samples in this manner.

206. (C) 3
In a goodness-of-fit test, the degrees of freedom are equal to the number of categories being compared minus one. For a dihybrid cross in Mendelian genetics, there are four expected phenotypic classes. Therefore, the degrees of freedom for the Chi-square test are three. This value is used to find the critical value needed to determine if the observed data deviates significantly from expectations.

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207. (D) The observed frequencies perfectly match the expected frequencies.
The Chi-square statistic measures the overall discrepancy between what is observed and what is expected. If the observed frequencies in every category are exactly equal to the expected frequencies, the numerator of every term in the formula becomes zero. Consequently, the total Chi-square value will be zero, indicating a perfect fit between the experimental data and the theoretical model being tested.

208. (B) $\frac{\text{Row Total} \times \text{Column Total}}{\text{Grand Total}}$
In a Chi-square test of independence, the expected frequency for each cell is calculated under the assumption that the two variables are

not related. This is done by multiplying the total of the row the cell belongs to by the total of its column, and then dividing that product by the overall grand total of all observations in the contingency table.

209. (A) I and II
The three basic principles of experimental design are randomization, replication, and local control. Randomization ensures that every plot has an equal chance of receiving any treatment, preventing bias. Replication involves repeating treatments to provide an estimate of experimental error and increase precision. While local control is also a core principle, its purpose is to decrease experimental error rather than increase it.

210. (D) Randomization
Randomization is a fundamental principle of experimental design that involves assigning treatments to experimental units by chance. This process is essential because it ensures that there is no systematic bias in how treatments are distributed, such as always placing one variety in the most fertile part of a field. It validates the use of probability theory in the subsequent statistical analysis.

211. (D) Increasing replication invariably completely eliminates experimental error.
Replication involves applying the same treatment to multiple experimental units. It is essential for estimating the variance of the experimental error and improving the precision of the estimated treatment means. While increasing the number of replications reduces the standard error of the mean and makes the experiment more sensitive, it can never completely eliminate experimental error, which is inherent in biological research.

212. (C) Creating homogeneous blocks to decrease overall error.
Local control, often achieved through blocking, is used to manage known sources of variation in the experimental area. By grouping similar experimental units into blocks, the researcher ensures that the variation within each block is minimized. This homogeneity allows the variation between blocks to be identified and removed during analysis, which decreases the experimental error and makes the treatment comparisons more precise.

213. (A) Completely Randomized Design (CRD)
The Completely Randomized Design is the simplest experimental layout. it relies entirely on the principles of randomization and replication. Because treatments are assigned to units across the entire experimental area without any grouping or blocking, it lacks the principle of local control. This design is most appropriate for laboratory or greenhouse studies where environmental conditions are already highly uniform and homogeneous.

214. (D) Randomization
Systematic bias occurs when extraneous factors consistently influence one treatment more than another. Randomization is the specific principle designed to combat this issue. By using a random process to assign treatments to plots, any underlying environmental or biological variation is distributed randomly among the treatments. This prevents external factors from being confounded with the actual treatment effects, ensuring a fair and unbiased comparison.

215. (B) Provides unbiased, precise, and testable estimates.
Using the principles of randomization, replication, and local control together ensures the integrity of an experiment. Randomization provides unbiased estimates, replication allows for the measurement of precision and statistical testing of differences, and local control improves that precision by reducing error. Together, they allow researchers to draw valid, reliable, and scientifically sound conclusions about the effects of the treatments being studied.

216. (C) To balance out systematic variations due to known fertility gradients.
Replication serves several critical roles, including providing an estimate of error, improving precision, and broadening the scope of the study. However, balancing out known systematic variations, like a fertility gradient, is the specific function of local control or blocking. While replication increases the number of observations, it does not inherently account for spatial patterns of soil variability without the use of blocks.

217. (D) The innate variation among identical experimental units treated alike.
Experimental error refers to the differences in results observed between experimental units that have been treated identically. This variation is

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caused by factors that the researcher cannot control, such as microscopic soil differences, genetic variability between individual plants, or small measurement inaccuracies. It provides the baseline of "noise" against which the "signal" of the treatment effects is compared during statistical analysis.

218. (A) The known fertility gradient or source of variation.
For local control to be most effective, blocks should be oriented so that the experimental units within each block are as similar as possible. If a field has a known fertility gradient, such as a slope or a drainage pattern, the blocks should be laid out perpendicular to that gradient. This ensures that the primary source of variation is captured between the blocks.

219. (B) $t(r-1)$
In a Completely Randomized Design, the total degrees of freedom are divided between treatments and the experimental error. For an experiment with 't' treatments and 'r' replications, the total number of observations is 'tr'. The degrees of freedom for treatments are t minus one, leaving t times r minus one degrees of freedom for the error term, which provides the estimate of variability.

220. (B) Experimental unit or plot
An experimental unit is the basic entity to which a single treatment is applied in an experiment. In field trials, this is typically a specific plot of land. In other contexts, it could be an individual animal, a single plant, or a petri dish. It is the smallest division of experimental material that can receive a treatment independently of other units.

221. (A) The assumption of independent, normally distributed errors is strictly violated, invalidating probability calculations.
Randomization is a strict requirement for valid statistical inference. Most statistical tests assume that the experimental errors are independent and randomly distributed. If a researcher assigns treatments systematically rather than randomly, this assumption is broken. This makes it impossible to accurately calculate the probability of the results, rendering any subsequent p-values or significance tests mathematically invalid and scientifically unreliable.

222. (C) The total variation in a dataset into defined components associated with specific sources.
Analysis of Variance is a powerful statistical method that breaks down the total variability observed in an experiment into different parts. These parts are attributed to specific known sources, such as the treatments being tested and the blocks used for control, as well as a remaining portion called experimental error. This allows researchers to test if treatment differences are statistically significant.

223. (A) General mean + Treatment effect + Random error
The linear model for a one-way ANOVA provides a mathematical description of each observation. It assumes that the value of any data point is the sum of the overall population mean, the specific effect of the treatment applied to that unit, and a random error term representing unexplained variation. This additive structure is the basis for partitioning the total variance in the dataset.

224. (C) Treatment effects and block effects are strictly multiplicative.
Standard ANOVA relies on several key assumptions to ensure accurate results. These include the independence of errors, the normality of error distribution, and the homogeneity of variances across groups. Additionally, the model assumes that treatment and block effects are additive, meaning they sum together. The assumption that these effects are multiplicative is incorrect and would require a different type of statistical model.

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225. (B) It calculates an unbiased estimate of the underlying population variance for that specific source.
Mean squares are calculated by dividing the sum of squares by the corresponding degrees of freedom. This operation is essential because the sum of squares grows with the number of observations, while the mean square provides a standardized measure of variability. The mean square serves as an unbiased estimate of the variance associated with a particular source, such as treatment or error.

226. (B) σ^2 (the true error variance)
In the Analysis of Variance, the error mean square is the fundamental measure of the unexplained variability in the experiment. Under the fixed-effects model, the mathematical expectation of the error mean square is equal to

to provide the same level of statistical precision. This indicates that the blocking in the RBD successfully reduced the experimental error.

246. (A) P-4, Q-3, R-2, S-1
Different experimental designs are chosen based on the characteristics of the material and the research goals. CRD is best for homogeneous material. RBD is used for one-way gradients with blocks. LSD controls for two-way variation using rows and columns. Split Plot design is used when two factors require different plot sizes, resulting in different levels of precision for each factor.

247. (B) 23
The total degrees of freedom in an experiment are always one less than the total number of experimental units. In an RBD with six varieties and four blocks, there are twenty-four total plots. Therefore, the total degrees of freedom in the ANOVA table are twenty-three. This total is then divided between blocks, treatments, and the resulting experimental error for the significance testing.

248. (C) Two orthogonal (perpendicular) dimensions simultaneously.
The Latin Square Design is a sophisticated experimental layout used to control variation in two different directions at once. It groups experimental units into both rows and columns. This two-way blocking allows the researcher to isolate and remove variation coming from two perpendicular gradients, such as a fertility change in one direction and a light gradient in another, improving precision.

249. (A) I, II, III and V
Latin Square Designs are governed by strict mathematical constraints. The design must be square, meaning the number of rows, columns, treatments, and replications are all identical. Every treatment must appear exactly once in each row and column. Additionally, the error degrees of freedom are specifically calculated as $(t-1)$ times $(t-2)$. These rules ensure that the two-way blocking is balanced and statistically valid.

250. (A) 12
In a Latin Square Design, the error degrees of freedom are determined by the number of treatments. For a five-by-five square, the formula is $(t-1)$ times $(t-2)$. Subtracting one from five gives four, and subtracting two from five gives three. Multiplying four by three results in exactly twelve degrees of freedom for the experimental error, which is used for the F-test in ANOVA.

251. (B) Column effect
The statistical model for a Latin Square Design expands upon the RBD model by adding another component. While the RBD model includes treatment and block effects, the LSD model includes effects for both rows and columns. This reflects the two-way blocking structure of the design and allows for the separate partitioning of variation associated with each of these two perpendicular dimensions.

252. (B) Large-scale varietal trials testing 50 new wheat genotypes simultaneously.
Latin Square Designs are not practical for a very large number of treatments because the number of replications must equal the number of treatments. A trial with fifty genotypes would require fifty rows and fifty columns, totaling two thousand five hundred plots. Managing such a large, perfectly square layout in the field while maintaining uniformity across such a vast area is virtually impossible.

253. (A) Fewer than 4 treatments yield an Error Mean Square with practically zero degrees of freedom, severely reducing test power; more than 8 requires excessively large, heterogeneous fields.
The use of LSD is generally limited to between four and eight treatments. With fewer than four, the error degrees of freedom are very low, making the test insensitive. With more than eight, the square layout becomes so large that it is difficult to maintain homogeneity within the rows and columns, leading to an increase in experimental error that negates the benefits of blocking.

254. (B) 12, 9, 6
For four treatments and four replications, different designs provide different error degrees of freedom. In a CRD, there are twelve error df. In an RBD, the error df is nine. In an LSD, which uses two-way blocking, the error df is further reduced to six. This reduction occurs because more variation is being partitioned into rows and columns, potentially leading to higher precision.

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236. (B) Perpendicular to the known fertility gradient.
To maximize the effectiveness of blocking in an RBD, each block should be as homogeneous as possible. If a field has a fertility gradient, such as nitrogen levels decreasing from north to south, the blocks should be laid out as long strips from east to west. This orientation ensures that the plots within each block have similar soil conditions, improving the precision of treatments.

237. (A) Replications or Blocks
The linear model for a Randomized Block Design adds a term to represent the effect of the blocks or replications. This acknowledges that observations are influenced not only by the treatment and random error but also by the specific block in which they are located. By including this effect, the model can mathematically separate the variation caused by blocks from the unexplained error.

238. (C) The number of blocks must be exactly equal to the number of treatments.
A standard RBD requires that every treatment appears once in each block, meaning the number of plots in a block must equal the number of treatments. However, there is no rule that the number of blocks must equal the number of treatments. Researchers can choose the number of blocks based on the desired level of replication and the available experimental material.

239. (D) Isolation of block variation from the error term decreases the Error Mean Square.
The primary advantage of the RBD is that it reduces the experimental error. In a CRD, any variation between blocks would be lumped into the error term, making it larger. In an RBD, this block variation is calculated and subtracted from the error sum of squares. This results in a smaller error mean square, which increases the sensitivity and power of the F-test.

240. (B) $(t-1)(r-1)$
In a Randomized Block Design with 't' treatments and 'r' blocks, the degrees of freedom for the experimental error are found by taking the product of the degrees of freedom for treatments and blocks. Since treatments have t minus one and blocks have r minus one degrees of freedom, their interaction, which serves as the error term, has $(t-1)$ times $(r-1)$ degrees of freedom.

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241. (B) When the experimental material exhibits a unidirectional, recognizable gradient of heterogeneity.
RBD is specifically designed for situations where there is a clear and predictable pattern of variation in the experimental area, such as a single fertility gradient. By aligning the blocks to account for this gradient, the researcher can control its influence on the results. If the area were perfectly uniform, a CRD would be sufficient, as blocking would not provide any additional benefit.

242. (D) Maintaining within-block homogeneity becomes difficult, increasing error variance.
As the number of treatments increases, each block in an RBD must also increase in size to accommodate them. Larger blocks are more likely to cover a wider area with greater soil variability, making it harder to keep the plots within each block homogeneous. This increase in within-block variation can lead to a larger error mean square, negating the precision benefits of the design.

243. (A) Treatment $\times$ Block Interaction
In the standard ANOVA for a Randomized Block Design, there is typically only one observation for each treatment-block combination. Because of this, it is mathematically impossible to separate the treatment-by-block interaction from the experimental error. The variation associated with this interaction is confounded with the error and is used as the basis for testing the significance of the main treatment effects.

244. (A) Both A and R are true and R is the correct explanation of A.
Analysis of Variance for an RBD assumes that treatments and blocks do not interact. Because there is only one plot for each treatment in every block, the statistical model cannot independently estimate a specific interaction term. Instead, any interaction that does exist is included in the residual sum of squares, which serves as the experimental error term for the entire analysis.

245. (A) CRD requires 40% more replications to achieve the exact same precision as the RBD.
Relative efficiency is a measure used to compare the precision of different experimental designs. If an RBD has a relative efficiency of one point four zero compared to a CRD, it means that the CRD would need forty percent more replications

it would be too large for the sub-plot factor, making real differences harder to detect.

283. (B) It is irregular, as Error(b) is usually smaller due to homogeneity.
In a well-conducted Split Plot experiment, Error(b) is almost always smaller than Error(a). This is because sub-plots are located closer together within the same main plot, reducing the influence of soil heterogeneity. If Error(a) is found to be smaller, it suggests that the blocking of the main plots was exceptionally effective or that some other irregularity occurred during the experiment.

284. (C) 18
The degrees of freedom for Error(b) in a Split Plot Design are calculated by multiplying the main plot degrees of freedom by the sub-plot degrees of freedom. For three blocks, three main plot levels, and four sub-plot levels, Error(a) has four df. Error(b) is calculated as the product of the number of main levels, the sub-plot levels minus one, and the blocks minus one.

285. (A) $Replication \times Main - plot\text{int}eraction$
In the mathematical partitioning of variance for a Split Plot Design, Error(a) represents the variation that cannot be explained by blocks or main-plot treatments. Statistically, this is the interaction between the replications and the main-plot factor. This term serves as the appropriate error for testing the main effects, accounting for the variation between the large-scale experimental units used in the design.

286. (C) Large main plots capture more unmeasured soil heterogeneity.
The sacrifice of precision for main-plot factors is a direct consequence of their size. Large plots are more likely to encompass a wider range of soil conditions and environmental variation than small sub-plots. This increased variability within the main plots leads to a larger Error(a) term, which makes it more difficult for the F-test to identify significant differences between the main-plot treatments.

287. (D) The overall ANOVA F-test for treatment effects is found to be statistically significant.
The Critical Difference test is a post-hoc procedure used to compare individual treatment means. It is only appropriate to perform this test if the initial F-test in the ANOVA has already rejected the null hypothesis. If the F-test shows no significant difference among treatments, any further comparisons between means are mathematically invalid and could lead to false conclusions based on random chance.

288. (B) $t_{\alpha} \times \sqrt{\frac{2 \times \text{Error Mean Square}}{r}}$
The Critical Difference is the minimum value by which two treatment means must differ to be considered statistically significant. It is calculated by multiplying the appropriate t-value for the error degrees of freedom by the standard error of the difference between the means. This formula identifies the threshold for significance at a chosen alpha level, such as five percent, for experimental trials.

289. (B) It can perfectly evaluate multiple completely independent continuous variables simultaneously.
The Critical Difference test is specifically designed for pairwise comparisons of means for a single dependent variable after a significant ANOVA result. It is not a multivariate tool and cannot simultaneously analyze multiple independent continuous variables. Other important assumptions include equal replication for the standard formula and the understanding that it does not fully control for inflated Type I error in multiple comparisons.

290. (B) Variance of the difference of independent means is the sum of their variances.
The formula for the Critical Difference includes the square root of two because it is based on the variance of the difference between two means. When subtracting one independent mean from another, the variance of the resulting difference is the sum of their individual variances. For equal replications, this sum is twice the variance of a single mean, requiring the square root of two.

291. (A) 3
The standard error of the difference between two means is calculated using the error mean square and the number of replications. With an error mean square of eighteen and four replications, the variance of a single mean is four point five. The variance of the difference is nine, which is twice four point five. Taking the square root of nine results in three.

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255. (D) Partitions two sources of error, providing higher precision than RBD.
The primary advantage of the Latin Square Design is its ability to account for more variation than the Randomized Block Design. By partitioning variation into both rows and columns, it removes more background noise from the error term. This often results in a smaller error mean square, which makes the design more efficient and precise for detecting significant differences between the treatments.

256. (C) Replications (as a separate factor from Rows/Columns)
In a Latin Square Design, the rows and columns themselves serve as the replicates for the treatments. Since every treatment appears exactly once in each row and column, the number of replications is inherently tied to the dimensions of the square. Therefore, unlike an RBD where blocks represent replications, an LSD ANOVA table partitions variation into rows, columns, and treatments.

257. (B) A strict 6×6 square grid containing 36 total plots.
The Latin Square Design requires a specific geometric layout to maintain its statistical balance. For six treatments, the design must consist of thirty-six plots arranged in a six-by-six grid. This structure ensures that each treatment is replicated six times and appears exactly once in every row and every column, fulfilling the requirements for two-way blocking and balanced randomization.

258. (D) The treatment effect is statistically non-significant.
In an ANOVA, the F-statistic is the ratio of the treatment mean square to the error mean square. If the error variation is much larger than the variation caused by the treatments, the resulting F-ratio will be small. Since a significant result requires the treatment variation to be much greater than the error, a very large error term typically leads to a non-significant conclusion.

259. (A) The first row and first column strictly follow an alphabetical or sequential order of treatments.
A standard Latin Square is a specific arrangement used as a starting point for randomization. In this square, the treatments in the first row and the first column are placed in their natural sequential or alphabetical order. From this standard square, researchers can generate all other possible Latin Squares through the process of random permutation of rows, columns, and treatment assignments.

260. (C) Randomly selecting a square from a set of all possible combinations, then randomly permuting all rows, and all columns independently.
To ensure that a Latin Square experiment is valid, the final layout must be chosen randomly. The process involves selecting a standard square and then randomly permuting all the rows and all the columns. Finally, the treatments are randomly assigned to the letters. this thorough randomization ensures that each treatment has an equal chance of appearing in any specific plot in the grid.

261. (A) Estimate the probable value of a lost observation to restore the mathematical balance of the design and allow standard ANOVA calculations.
ANOVA calculations for designs like RBD and LSD rely on the data being balanced and complete. If a plot is lost due to an accident or disease, this balance is broken, making standard formulas difficult to use. The missing plot technique provides a mathematical way to estimate the most likely value for that missing point, restoring the symmetry required for analysis.

262. (A) $\frac{rB + tT - G}{(r-1)(t-1)}$
When a single plot is missing in a Randomized Block Design, its value can be estimated using a specific formula. This formula uses the number of replications and treatments, along with the totals for the block and treatment where the plot was lost, and the grand total of all available plots. This calculation provides the least squares estimate for the missing observation.

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263. (B) The procedure perfectly recovers the exact biological value that was lost.
The missing plot technique is a mathematical tool designed to facilitate statistical analysis, but it has limitations. It provides a statistical estimate that minimizes the error sum of squares, but it cannot perfectly recover the true biological value that would have been observed. Furthermore, degrees of freedom must be reduced in the ANOVA to account for the use of estimated data.

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all other successful observations in that block must be ignored. Estimating the missing value allows the researcher to use the rest of the data, maintaining the statistical power and efficiency of the experiment.

274. (D) One factor physically or practically requires larger experimental units than the other factor.
The Split Plot Design is used for factorial experiments where the treatments for one factor need a larger area than the treatments for another. For example, irrigation requires large plots for pipes, while fertilizer can be applied to small sub-sections. This design organizes the experiment into main plots for the large-scale factor and sub-plots for the smaller-scale factor within them.

275. (A) Randomized independently within each individual main plot.
In a Split Plot Design, randomization happens in two stages. First, the levels of the main plot factor are randomly assigned to the main plots within each block. Second, for each individual main plot, the levels of the sub-plot factor are randomized independently. This hierarchical randomization reflects the physical structure of the plots and is a defining characteristic of the split-plot layout.

276. (C) It strictly produces two distinct error terms: Error(a) for main plots and Error(b) for sub-plots.
The Analysis of Variance for a Split Plot Design is unique because it partitions the experimental error into two separate parts. Error(a) is used to test the significance of the main plot factor, while Error(b) is used to test the sub-plot factor and the interaction between the two. This structure accounts for the different plot sizes and randomization levels used in the design.

277. (A) Sub-plots use a more homogeneous local environment, lowering Error(b).
Sub-plot treatments are compared within the smaller, more uniform area of a single main plot. This close proximity reduces the environmental variation between them. In contrast, main-plot treatments are compared across larger areas that may have more soil variability. As a result, Error(b) is typically smaller than Error(a), making the design more precise for sub-plot factors and their interactions.

278. (D) Irrigation scheduling (applied via massive overhead sprinklers)
Irrigation is a classic example of a main-plot factor in agricultural trials. Because massive sprinklers or irrigation systems cannot easily be applied to small, scattered plots, they must be assigned to large contiguous areas. Other factors like different crop varieties or fertilizer rates can be easily managed within those large areas, making them ideal as sub-plot treatments in a split-plot experiment.

279. (B) RBD with a treatments and r blocks
In a Split Plot Design, the main plots are organized into a structure that is mathematically identical to a Randomized Block Design. If the sub-plot factor is ignored, the main plots receive 'a' treatments across 'r' replications. Therefore, the degrees of freedom and the calculation for Error(a) are the same as those used for the error term in a standard one-factor RBD.

280. (C) Error(b)
The interaction between the main plot factor and the sub-plot factor is evaluated at the sub-plot level. Because the interaction effects are measured within the smaller, more precise units, the significance of the interaction is tested using the sub-plot error term, Error(b). This provides a more sensitive test for detecting how the two factors influence each other in the agricultural experiment.

281. (D) Completely Randomized Design
A Completely Randomized Design is unsuitable for experiments where factors have different plot size requirements or spatial constraints. If sowing dates must be applied in large strips and varieties in smaller plots, a design that incorporates blocking and hierarchical plots is necessary. CRD's total randomization across the entire area would be practically impossible to implement for irrigation or large-scale sowing machinery.

282. (A) Main effects will be overestimated; sub-plot effects will be underestimated.
Analyzing a Split Plot Design as a standard factorial RBD is a mistake because it uses a single pooled error term. Since the main plot error is usually larger than the sub-plot error, a pooled error would be too small for the main factor, leading to false significance. Conversely,

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the true variance of the population error. This value provides the necessary denominator for the F-test, representing the "background noise" against which treatments are evaluated.

227. (A) It becomes significantly larger than σ^2 due to the added variance component of the treatments.
If the null hypothesis in an ANOVA is true, the treatment mean square only reflects random error and should be close to the error mean square. However, if the treatments actually have different effects, the treatment mean square will include both the random error and a component representing the true variation between the treatments. This makes the treatment mean square significantly larger than σ^2.

228. (C) Provides a systematic and verifiable summary of variance partitioning and significance testing.
An ANOVA table is a standardized way to present the results of an experiment. It neatly organizes the degrees of freedom, sums of squares, mean squares, and the final F-statistic for each source of variation. This structure allows researchers and reviewers to easily verify the calculations and see the relative importance of different factors, providing a clear summary of the statistical evidence.

229. (C) IV
To construct a complete ANOVA table, researchers must calculate the degrees of freedom, the sum of squared deviations from the mean, and the resulting mean squares for each source of variation. These values are used to determine the F-ratio. While standard deviations are related to these measures, they are not a standard required component of the table itself, which focuses on variances.

230. (A) Total SS = Treatment SS + Error SS
In a one-way ANOVA, the total variability in the dataset, measured by the total sum of squares, is partitioned into two mutually exclusive parts. The first part is the variation between the treatment groups, and the second part is the variation within the groups, which is the error. The sum of these two components must always equal the total sum of squares.

231. (B) Square of the Grand Total divided by the total number of observations.
The correction factor is a value used in the computational shortcut for calculating the sum of squares. It is found by squaring the sum of all individual observations in the experiment and then dividing that result by the total count of those observations. This factor is subtracted from the sum of the squared values to find the actual variation around the mean.

232. (C) The ratio of two independent chi-square variables, each divided by their degrees of freedom, follows an F-distribution.
The validity of the F-test in ANOVA is rooted in the mathematical properties of the chi-square and F-distributions. When the assumptions of normality and independence are met, the mean squares for treatment and error behave like independent chi-square variables. The ratio of these two mean squares follows an F-distribution, providing the theoretical basis for determining the significance of the results.

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233. (D) Block variation
In a Completely Randomized Design, there is no local control or grouping of experimental units. Therefore, the total variation is only divided into two sources: treatments and error. Block variation is a component that is specifically partitioned out in designs like the Randomized Block Design, where blocks are used to manage heterogeneity. In a CRD, any such variation remains part of the error term.

234. (A) 7.5
In a CRD with four treatments and five replications, there are twenty total plots and sixteen degrees of freedom for error. The error sum of squares is found by subtracting the treatment sum of squares (eighty) from the total sum of squares (two hundred), giving one hundred and twenty. Dividing the error sum of squares by sixteen error degrees of freedom results in seven point five.

235. (B) Local Control (Blocking)
The Randomized Block Design is an improvement over the Completely Randomized Design when the experimental area is not uniform. It incorporates the principle of local control by grouping similar experimental units into blocks. This allows the researcher to account for variation from environmental gradients, such as soil fertility or light, which would otherwise be included in the experimental error term in a CRD.

292. (C) The two means are statistically significantly different.
To determine if the difference between two treatments is meaningful, the observed difference between their means is compared to the calculated Critical Difference. If the absolute difference in the sample is larger than the CD value, the null hypothesis is rejected. Since five kilograms is greater than the CD of three point five kilograms, the researcher concludes that the two varieties differ significantly.

293. (A) Family-wise Type I error rate inflates far beyond the set alpha level.
Fisher's Least Significant Difference test is used for comparing pairs of means. However, when many comparisons are made in one experiment, the probability of finding at least one "significant" difference purely by chance increases. For twenty comparisons at a five percent level, the total risk of a Type I error across all tests becomes much higher than the five percent originally intended.

294. (D) Fisher's basic Critical Difference (without significant prior F)
Multiple comparison procedures like Tukey's HSD and Duncan's DMRT are specifically designed to control the inflated risk of Type I errors when making many comparisons. Fisher's basic Critical Difference, if used without a prior significant F-test or on a large number of pairs, does not offer this protection. It is the most liberal test and is more likely to produce false positive results.

295. (B) t-table value strictly at Error degrees of freedom for a two-tailed test
Calculating the Critical Difference requires a multiplier from the Student's t-distribution. The researcher identifies the t-value that corresponds to the desired significance level, usually five percent, and the specific degrees of freedom associated with the error mean square in the ANOVA table. This t-value ensures that the threshold for significance is correctly scaled for the size and variability of the experiment.

296. (C) The CD strictly equals zero, implying any minute mathematical difference between sample means is deemed "significant."
If the error mean square is zero, it means there is no variation at all within the treatment groups. In the CD formula, multiplying by an error of zero results in a Critical Difference of zero. In this theoretical scenario, any difference between two treatment means, no matter how tiny, would be considered statistically significant because there is no "noise" to obscure the results.

297. (D) Inflating the SED using a specific adjustment factor for lost data.
When a dataset includes estimated values for missing plots, the precision of the means is reduced. To account for this, the standard error of the difference must be adjusted. An inflation factor is applied to the SED formula, which makes the Critical Difference larger. This ensures that the test remains valid and compensates for the missing biological information from the original experiment.

298. (A) Only for specifically planned pre-planned orthogonal contrasts or when the overall F-test is significant for a small number of unstructured treatments.
Modern statisticians recommend using the Critical Difference test cautiously. It is most appropriate for specifically planned comparisons that were decided before the data was collected, or for analyzing experiments with a small number of treatments after the overall F-test has shown significance. For experiments with many treatments, more conservative multiple comparison tests are preferred to ensure the reliability of the findings.

299. (B) They are not strictly significantly different from each other at the specified alpha level.
In research papers, treatment means are often followed by letters to show the results of post-hoc tests. If two treatments share the same letter, it means the difference between them is smaller than the Critical Difference or the range value for that test. Therefore, the researcher cannot conclude that those treatments are significantly different from each other at the chosen level of significance.

300. (C) $SED = SEm \times \sqrt{2}$
Statistical comparisons between two treatment means depend on the variability of those means. The standard error of a single mean represents individual precision, while the standard error of the difference measures the precision of the comparison itself. Mathematically, the difference between two independent means incorporates the variance of both, leading to a standard error value multiplied by the square root of two.

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264. (C) To strictly minimize the error sum of squares (least squares estimation).
The formulas used to estimate missing values are derived based on the principle of least squares. The objective is to find a value that, when inserted into the dataset, results in the smallest possible error sum of squares for the given model. This ensures that the estimated value is consistent with the remaining observations and does not artificially inflate the experimental error.

265. (D) The row total, column total, treatment total (of the missing plot's assigned treatment), and the grand total.
Estimating a missing plot in a Latin Square Design is more complex than in an RBD because of the two-way blocking. The formula requires the totals for the specific row and column where the plot was located, as well as the total for the treatment that was assigned to that plot. These values, along with the grand total, are used to calculate the estimate.

266. (A) 8
In an RBD with four treatments and four blocks, the standard error degrees of freedom would be nine. However, when the missing plot technique is used to estimate one lost observation, one degree of freedom must be subtracted from both the total and the error terms. This adjustment accounts for the fact that one data point was estimated rather than measured directly.

267. (B) Treatment Sum of Squares
After estimating a missing plot and performing the ANOVA, the treatment sum of squares is often biased upward. This happens because the estimated value was chosen specifically to minimize the error, which can make the treatment effects appear stronger than they actually are. A specific mathematical correction is applied to the treatment sum of squares to remove this bias and ensure a valid F-test.

268. (B) Completely Randomized Design
The Completely Randomized Design is a non-orthogonal design that can easily handle unequal numbers of replications for different treatments. If a plot is lost, the researcher simply performs the analysis with the remaining data. Because there are no blocks or rows to maintain, there is no mathematical need for missing plot formulas to restore balance in a CRD experiment.

269. (A) The standard error is increased, requiring a specific adjusted mathematical formula.
When comparing two treatment means where one or both involve estimated missing values, the standard error of the difference is affected. Because estimated data is less certain than measured data, the precision of the comparison is reduced. An adjusted formula is used to calculate a slightly larger standard error, reflecting the increased uncertainty caused by the loss of the original experimental observations.

270. (B) 17
The total degrees of freedom for an experiment are equal to the number of available observations minus one. In an RBD with five treatments and four blocks, there were originally twenty plots. If two plots are lost, only eighteen observations remain. Therefore, the total degrees of freedom in the final adjusted ANOVA table will be exactly seventeen, regardless of the missing plot estimation.

271. (D) Grand total of all available valid observations in the experiment.
In the formula for estimating a missing plot in an RBD, the symbol 'G' represents the sum of every single data point that was successfully collected in the entire experiment. It excludes the missing plot itself. This grand total of valid observations is a necessary component for balancing the estimated value against the overall average and the specific treatment and block totals.

272. (C) Substituting a guessed mean for the first missing plot, calculating the second via formula, then using that to recalculate the first, repeating until values stabilize.
When multiple plots are missing, the estimation process becomes an iterative cycle. A researcher begins by making an initial guess for one value and then uses the formula to calculate the other. This new value is then used to refine the first estimate. This process is repeated until the values stop changing significantly, ensuring the best possible least squares estimates for all missing points.

273. (B) Ignoring blocks wastes valid data collected from other treatments.
The missing plot technique is preferred over discarding entire blocks because it preserves as much information as possible. In a large experiment, losing one plot should not mean that

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